THE ORDOVICIAN TRILOBITE FAUNAS OF SOUTH SHROPSHIRE, I

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SYNOPSIS

This paper is the first of four in which the trilobite faunas of the Ordovician rocks in Shropshire south-east of The Longmynd are to be described and figured. The families Raphiophoridae and Trinucleidae are dealt with first, covering a total of eight genera, of which two, *Ampyxella* and *Smeathenia*, are new, and twenty-two species. As a result of the re-examination of the Trinucleidae in south Shropshire the relationships and possible evolution of the genera concerned is discussed.

I. INTRODUCTION AND ACKNOWLEDGMENTS

THE rocks of the Caradoc Series in the type-area of south-east Shropshire have long been famous for their prolific shelly faunas. Although the brachiopods predominate numerically there is an abundant and often well-preserved trilobite fauna which has, as yet, been only partially described. In 1839 Murchison (pl. 23, fig. 9) figured what he called *Asaphus powisii*; his illustrations of specimens attributed to the species included the cephalon of a phacopid from south Shropshire, but this error was later rectified when he referred the same cephalon to *Phacops conophthalmus* (*sic*) (1854 : 87). Also in his 1839 work Murchison (pl. 23, figs. 1 *d–f* only) employed as some of his syntypes of *Trinucleus caractaci* three cephala of the trinucleid known now as *Onnia superba* (Bancroft). Between 1846 and 1853 seven species which have been reported from south Shropshire were described or figured by both McCoy and Salter; these included *Acidaspis caractaci*, *Calymene blumenbachi* var. *caractaci*, *Chasmops macrourus*, *Homalonotus bisulcatus*, *H. rudis*, *Lichas laxatus* and *Phacops apiculatus*.

During the remainder of the nineteenth century only one other species was added to the literature, *Ampyx pennatus* (La Touche, 1884, pl. 3, fig. 56); this was inadequately figured, and the exact form was unknown until revised by Reed (1932 : 205, pl. 11, figs. 5–7). In the same paper Reed erected one other Shropshire species which he named *Ampyx* (*Raphiophorus*) *edgelli*. During this same general period Bancroft (1929*a*) established several new genera and species of Trinucleidae, and although his conclusions were not at once generally accepted, subsequent research has shown many of his genera and species to be of great taxonomic and stratigraphical value.

In 1931 Shirley (p. 25, pl. 2, figs. 4–6) redescribed the type-specimens of *Calymene caractaci* Salter, and later (1936) described from Shropshire two new species, *Reacalymene pusulosa* and *Flexicalymene onniensis*, the exact distribution of these forms being then virtually unknown.

The last of Bancroft's contributions to our knowledge of the Caradoc trilobites was published in 1949, five years after his death, and although the horizons of his type-specimens were given, there was no indication of the vertical and horizontal distribution of each species. Much of Bancroft's work suffered from lack of adequate detailed diagnoses and descriptions, and even at the present day photographs of all his type-specimens have not yet been published.

Recently Whittard (1958) has described and figured from the Shelve Inlier of west Shropshire certain species of trilobites which occur also in south Shropshire, and the present writer has reviewed the stratigraphy and faunas of the type-succession (Dean, 1958).

The present work is founded essentially on trilobites contained in the Bancroft Collection, purchased by the Trustees of the British Museum (Natural History) in 1936, and on extensive collections made by the writer since the summer of 1952. The material studied comprises several hundred well-localized specimens from horizons throughout the Caradoc Series in south Shropshire. In view of the large number of species involved it has been found convenient to subdivide the work, which will appear in four parts on the basis of the included trilobite families. The present paper will deal with trilobites having a marginal suture and without the normal paired eyes, represented by the Raphiophoridae and Trinucleidae. Later it is intended to cover the proparian, gonatoparian and opisthoparian forms. In addition to the collections already mentioned others have been consulted, and I wish particularly to thank the following for permitting the examination and loan of specimens in their care: Mr. A. G. Brighton (Sedgwick Museum, Cambridge), Dr. Gunnar Henningsmoen (Paleontologisk Institut, Oslo), Dr. Valdar Jaanusson (University of Uppsala), Miss Geraldine Roche (National Museum of Ireland), Mr. J. D. D. Smith (Geological Survey & Museum) and Mr. J. T. Wattison (Shrewsbury Museum and personal collection). The research was commenced at the University of Bristol during the tenure of a Post-Graduate Research Scholarship awarded by the Shell Petroleum Co. Ltd., to whom I am grateful for financial assistance. I am much indebted to Professor W. F. Whittard, not only for supervising the initial research but also for helpful advice and discussion since that time, and for reading and criticizing the manuscript. Finally, several of the photographs have been taken by Mr. E. W. Seavill (University of Bristol), and Mr. J. Brown and Mr. P. Green (British Museum (Natural History)); to all these gentlemen I wish to express my thanks for their skill.

II. STRATIGRAPHICAL SUMMARY

The stratigraphical subdivisions of the Caradoc Series which are established on lithology alone are largely the result of the pioneer work of Salter & Aveline, Lapworth, and others. The faunal subdivisions are those proposed by Bancroft (1928, 1928*a*, 1929, 1929*a*, 1933) who erected them on trilobites and brachiopods. Recently the whole question of the succession of shelly faunas in the Caradoc Area, and their correlation with the graptolitic faunas has been reviewed in detail (Dean, 1958), and the results are summarized below. An accompanying table shows the correlation of Stages, lithological subdivisions and graptolite-zones.

The lowest Caradoc strata of south Shropshire belong to the COSTONIAN STAGE, which is equated with an as yet undetermined upper part of the Zone of *Nemagraptus gracilis* on the basis of graptolites found in intercalated shale bands in the northern part of the outcrop. In the southern Caradoc Area, at and near the type-locality of Coston, the succession, to which the name Coston Beds has been given, is essentially an arenaceous one, commencing with unfossiliferous basal conglomerates. These pass upwards into the *Harknessella* Beds, rich in brachiopods, which are followed in turn by the *Costonia ultima* Beds, massive, bedded sandstones in which the zonal trilobite is common. North of the ridge of Pre-Cambrian rocks forming the Cardington Hills the succession is more calcareous than at Coston, but again the uppermost beds are characterized by the presence of *Costonia*, though a different species.

As the result of faulting at the type-locality of Coundmoor Brook, near Cressage, the HARNAGIAN STAGE at that point includes only the lowest of the three zones usually assigned to it, that of *Reuscholithus reuschi*. The succession includes a very thin basal sandstone conformably overlying sandy Costonian beds, and a series of

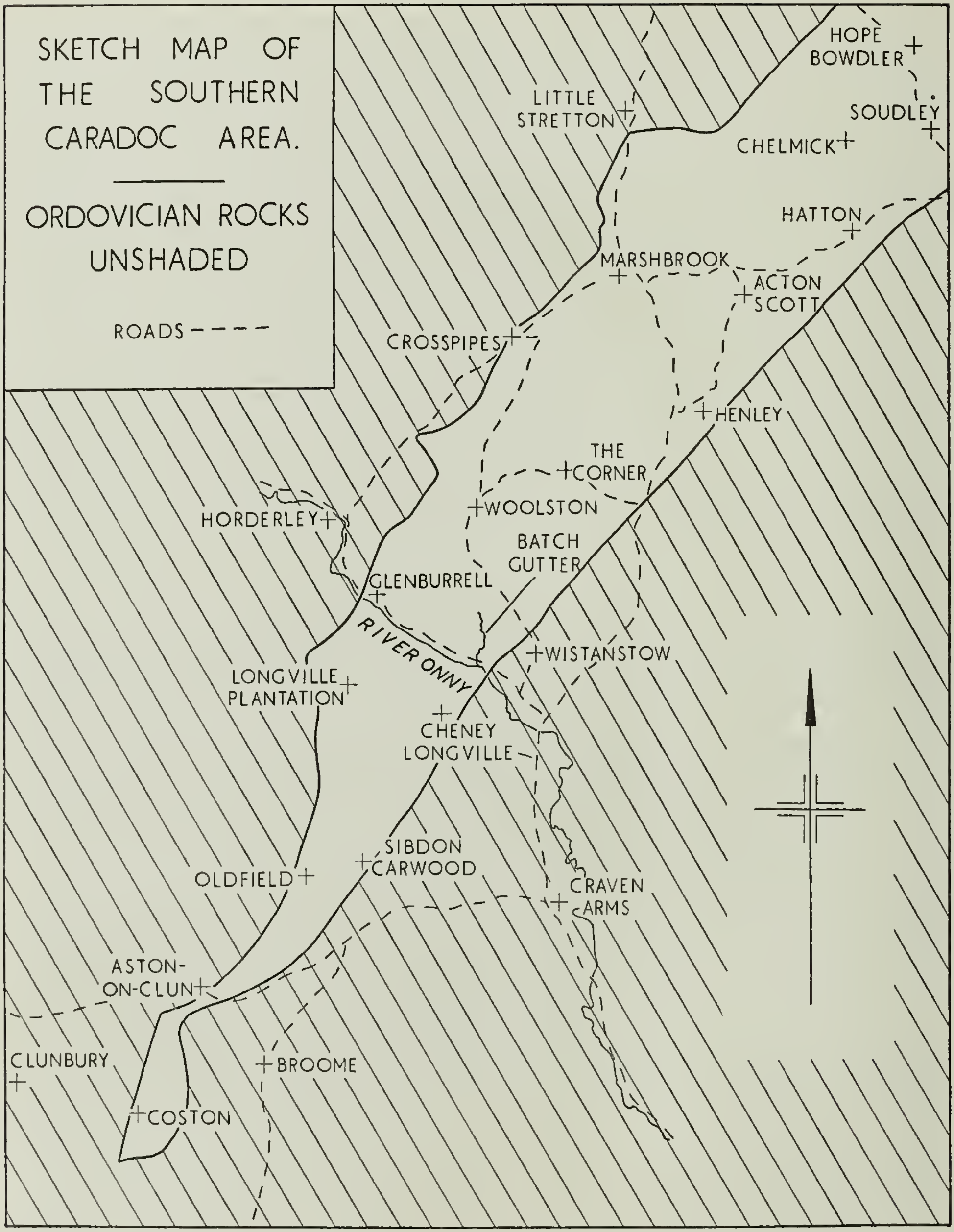
SKETCH MAP OF THE SOUTHERN CARADOC AREA.
ORDOVICIAN ROCKS UNSHADED
ROADS
HOPE BOWDLER
LITTLE STRETTON
SOUDLEY
CHELMICK
HATTON
MARSHBROOK
ACTON SCOTT
CROSSPIPES
HENLEY
THE CORNER
WOOLSTON
HORDERLEY
BATCH GUTTER
GLENBURRELL
RIVER ONNY
WISTANSTOW
LONGVILLE PLANTATION
CHENEY LONGVILLE
SIBDON CARWOOD
OLDFIELD
CRAVEN ARMS
ASTON-ON-CLUN
CLUNBURY
BROOME
COSTON

FIG. 1.

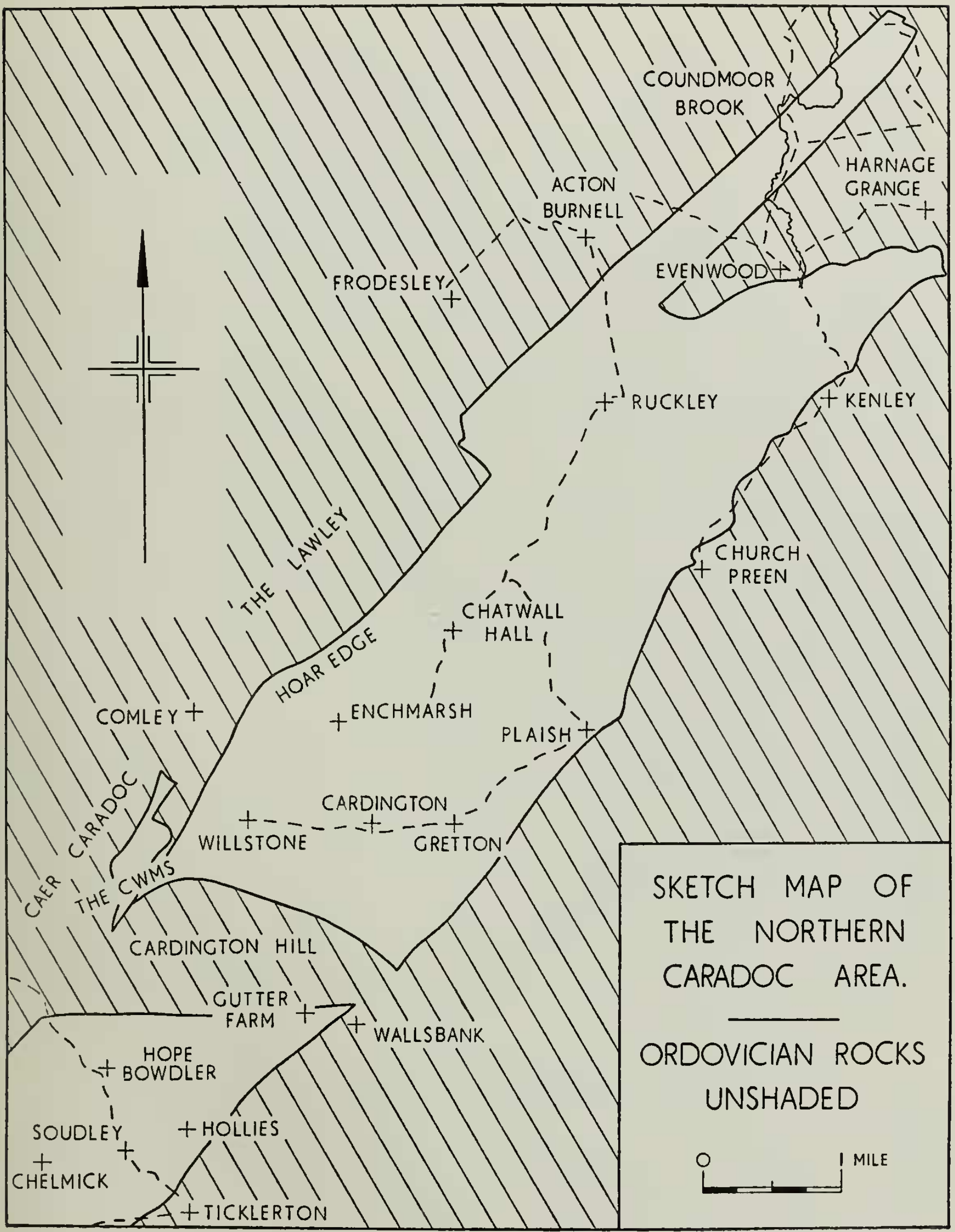
COUNDMOOR BROOK
HARNAGE GRANGE
ACTON BURNELL
FRODESLEY
EVENWOOD
RUCKLEY
KENLEY
THE LAWLEY
CHURCH PREEN
CHATWALL HALL
HOAR EDGE
COMLEY
ENCHMARSH
PLAISH
CAER CARADOC
CARDINGTON
WILLSTONE
GRETTON
THE CWMS
CARDINGTON HILL
GUTTER FARM
WALLSBANK
HOPE BOWDLER
SOUDLEY
HOLLIES
CHELMICK
TICKLERTON
SKETCH MAP OF THE NORTHERN CARADOC AREA.
ORDOVICIAN ROCKS UNSHADED
0
1 MILE

FIG. 2.

grey mudstones and shales which are the only Caradoc strata of south Shropshire to have yielded graptolites in significant numbers. Most of these beds contain, in addition to *Reuscholithus*, other trinucleids which were originally referred to *Salterolithus*, but which are now thought to be primitive members of *Broeggerolithus*. The base of the Harnagian is provisionally equated with the line separating the *Nemagraptus gracilis* and *Diplograptus multidens* Zones. To the south, at Hazler Hill, east of Church Stretton, neptunian dykes found in fissures in Pre-Cambrian rocks contain a fauna of early Harnagian age. In the Onny Valley district the Harnagian succession commences with a series of yellow, blocky mudstones, known as the Smeathen Wood Beds, which belong to the *Reuscholithus reuschi* Zone and the succeeding *Salterolithus caractaci* Zone. The Smeathen Wood Beds are followed by dark-green mudstones, the Glenburrell Beds, which have been divided into two trilobite-zones, a lower of *Ulricholithus ulrichi* (Bancroft) and an upper of *Broeggerolithus broeggeri* (Bancroft). The *U. ulrichi* Zone was retained by Bancroft in the Harnagian on account of the supposed affinity of *Ulricholithus* with *Salterolithus*, and the appearance of *Broeggerolithus* in the *B. broeggeri* Zone was said to mark the beginning of the SOUDLEYAN STAGE. Bancroft maintained that *Ulricholithus* bore no relationship to *Broeggerolithus* as typified by *B. broeggeri* but, as will be discussed in a later part of this work, *Ulricholithus* is probably best placed in the synonymy of *Broeggerolithus* and does not appear to be so closely related as was first thought to *Salterolithus*, a genus which extends with little modification upwards into the *B. broeggeri* Zone. Although trinucleids believed to belong, or be closely related, to *Broeggerolithus* occur as low as the early Harnagian it is not proposed to change the level of the dividing line between Harnagian and Soudleyan. Such a course would not serve any useful purpose, as the fauna of the newly renamed *Broeggerolithus ulrichi* Zone is imperfectly known, and in any case the drawing of the lower limit of the Soudleyan below the *B. broeggeri* Zone receives support from the available brachiopod evidence. The upper zone of the Soudleyan, that of *Broeggerolithus soudleyensis* (Bancroft), marks a change from mudstones to arenaceous strata, and is represented by the Lower Horderley Sandstone, or *Glyptocrinus* Flags, in the Onny Valley district ; farther north the same horizon is known variously as the Soudley Sandstone and the Lower Chatwall Sandstone or Chatwall Flags. Such scanty evidence as exists suggests that the junction of the Zones of *Diplograptus multidens* and *Dicranograptus clingani* may conveniently be taken between the Soudleyan and the succeeding LONGVILLIAN STAGE (Dean, 1958 : 229), but the problem has not yet been resolved sufficiently accurately.

The large vertical extent of the strata belonging to the Longvillian Stage has necessitated its subdivision into Lower and Upper Substages. The Lower Longvillian is probably confined to that part of the Caradoc Area lying to the south of the Cardington Hills, and even there it is occasionally cut out by disconformity and overstep. The fullest and best-exposed development is in the Onny Valley where the substage comprises the Middle and Upper Horderley Sandstones. These consist of brown, purple and green, massive and flaggy sandstones with impersistent lenticular limestone bands made up almost entirely of brachiopod shells. *Dalmanella* is abundant, and the species *D. horderleyensis* (Whittington), *D. indica* (Whittington) and *D. lepta*

(Bancroft), together with *Bancroftina typa* (Whittington), enable the rocks to be divided into three brachiopod zones. The trinucleid *Broeggerolithus globiceps* (Bancroft) is characteristic of the whole of the substage.

The basal member of the Upper Longvillian Substage is known as the *Alternata* Limestone, from the eponymous brachiopod *Heterorthis alternata* (J. de C. Sowerby). The strata are green, flaggy siltstones with lenticular limestone bands which die out upwards, the resulting series of uniform flaggy siltstones being known as the Lower Cheney Longville Flags. In the Onny Valley the *Alternata* Limestone follows the Upper Horderley Sandstone with apparent conformity, but farther north, at Soudley, it rests on Soudleyan beds, the Soudley Sandstone. Still farther north, beyond the Cardington Hills, it has been suggested that the Upper Chatwall Sandstone is an arenaceous facies of the basal Upper Longvillian which may again rest disconformably on Soudleyan strata (Dean, 1958 : 216). The lower part of the Upper Longvillian is characterized by the brachiopod *Kjaerina bipartita* (Salter) and the upper part by *Kjaerina geniculata* Bancroft, *K. typa* Bancroft and *Dolerorthis duftonensis* (Reed), whilst *Broeggerolithus longiceps* (Bancroft) appears to range through the substage.

The rocks constituting the MARSHBROOKIAN STAGE follow the Upper Longvillian with little change of lithology in the vicinity of the Onny Valley, where they are known as the Upper Cheney Longville Flags. *Broeggerolithus transiens* (Bancroft) is characteristic of the Stage, and the brachiopods enable the succession to be subdivided into three Zones of *Dalmanella wattsi* (Bancroft), *D. unguis* (J. de C. Sowerby) and *Onniella reuschi* Bancroft. The uppermost of these marks a transition to the ACTONIAN STAGE, an horizon which consists only of grey mudstones with thin limestones in the Onny Valley, but which includes some sandy strata, the Acton Scott Beds, farther north. *Platylichas laxatus* (McCoy) is fairly characteristic and abundant, accompanied by abundant *Chasmops*, rare *Calyptaulax*, and large numbers of brachiopods, particularly *Cryptothyris paracyclica* (Bancroft) and *Onniella* spp.

Outcrops of the succeeding ONNIAN STAGE are recorded only from the Onny Valley where they are given the name *Onnia* Beds after the contained trinucleid genus, and divided into three Zones of *Onnia? cobboldi* (Bancroft), *O. gracilis* (Bancroft) and *O. superba* (Bancroft). The rocks are grey and yellow mudstones, not very different from those of the Actonian, and the strata of these two Stages are believed to belong to the upper portion of the Zone of *Dicranograptus clingani.*

III. SYSTEMATIC DESCRIPTIONS

Family RAPHIOPHORIDAE Angelin, 1854

Angelin's Family Raphiophoridae was erected to include the genera *Ampyx* Dalman, *Lonchodomas* Angelin and *Raphiophorus* Angelin. Recently the type-species of these three have been redescribed by Whittington (1950) who has also included in the family the genera *Ampyxina* Ulrich and *Raymondella* Reed.

Among the Raphiophoridae recorded from the Caradoc Area is *Ampyx* (*Raphiophorus*) *edgelli* Reed, which occurs in the Actonian and Onnian Stages of the Caradoc Series. Whittington (1950 : 553) has described the type-species of *Raphiophorus* as being founded upon an unsatisfactory specimen, and has recommended that the name should not be used except for the type-species. Whether or not this course is advisable, and since then Whittard (1955 : 23) has continued to use the generic name in describing material from the Shelve Inlier, Whittington's photograph of the holotype of *Raphiophorus setirostris* Angelin shows the pygidium to be totally different from that of the Shropshire species, even though the cephalon of the Scandinavian specimen is partly crushed and therefore difficult to define.

The cephalon of Reed's species compares with that of the type-species of *Ampyx*, *A. nasutus* Dalman (Whittington, 1950, pl. 74, fig. 3), but has a median ridge running from the base of the frontal spine back to the occipital furrow. In addition, the pleural lobes of the pygidium are clearly ribbed and distinct from those of *A. nasutus* which bear only one pair of pleural furrows. At the time of Reed's description the thorax of *A.* (*R.*) *edgelli* was unknown, but recently two whole individuals have been examined, one collected by Professor Whittard (Bristol University 8312) and another in the Sedgwick Museum (A. 43831) ; each of these shows the thorax to be composed of five segments. In view of the form of the glabella, the composition of the thorax and the characteristically segmented lobes of the pygidium it is suggested that *A.* (*R.*) *edgelli* should become the type-species of a new genus for which the name AMPYXELLA is proposed.

Genus ***AMPYXELLA*** nov.

DIAGNOSIS. Cephalon sub-triangular in outline, with the glabella produced anteriorly to form a long spine which is quadrate and prismatic in cross-section. Median carina present on the glabella. Thorax composed of five segments of typical raphiophorid form, the first being macropleural. Pygidium subtriangular in outline. Axis tapers to the posterior extremity of the pygidium, and has numerous small axial rings which diminish in size rearwards. Pleural lobes carry an average of seven well-defined pleurae which extend outwards from the axial furrows to a small raised rim marking the margin of the pygidium.

DISTRIBUTION. The type-species has been found only in the Actonian and Onnian Stages of south Shropshire, but other forms which may possibly be referred to the new genus are recorded from as low as the Arenig Series in Scandinavia.

DISCUSSION. In addition to the type-species, *Ampyxella* possibly also includes *Ampyx latus* McCoy (1851 : 147, pl. 1E, figs. 13, 13*a*), *Ampyx volborthi* Schmidt (1894 : 80, pl. 6, figs. 11–20), a species which Skjeseth (1952 : 178) refers incorrectly to *Lonchodomas* merely on account of its having a prismatic frontal spine, and *Ampyx*? *aculeatus* Angelin (1854 : 81, pl. 40, figs. 5–5*c*).

TYPE-SPECIES. *Ampyx* (*Raphiophorus*) *edgelli* Reed, 1932.

Ampyxella edgelli (Reed)

(Pl. 11, figs. 1, 3, 4, 6 & 7)

1932. *Ampyx* (*Raphiophorus*) *edgelli* Reed, p. 207, pl. 11, figs. 1–4.
1949. *Raphiophorus edgelli* (Reed) Bancroft, p. 300, pl. 10, fig. 18.

Some details are in need of revision in the description supplied by Reed for the species. His figure of the cranidium (1932, pl. 11, fig. 1) shows the length of the glabella, from the occipital furrow to the base of the frontal spine, to be equal to the maximum breadth. Unfortunately the figured cranidium was a slightly flattened specimen and, in actual fact, the breadth is about two-thirds of the length, and the anterior portion of the glabella is almost pointed. A median ridge extends forwards from the occipital furrow as far as the front of the glabella ; at this point it appears, in plan, to divide owing to the development of a median groove which extends forwards to the tip of the frontal spine. Similar grooves are to be found on the sides and undersurface of the frontal spine, resulting in a fluted, quadrilateral cross-section.

The thorax consists of five segments, the axis being narrow, varying from rather less to rather more than one-quarter of the total breadth in uncrushed material. In a flattened specimen the axis appears somewhat broader. The side lobes are wide and flat, and the thorax attains its maximum breadth across the second and third segments. The first thoracic segment is macropleural, the anterolateral edges running obliquely backwards and outwards from the fulcral processes to the pleural points. Each pleura carries a moderately impressed pleural furrow which commences near the anterior margin at the axial furrow and then runs outwards and slighty backwards towards the pleural point. According to Reed the pygidium has five to six pleurae on each pleural lobe, but one of his figures (1932, pl. 11, fig. 4) shows a specimen with seven pleurae and this has been found to be the more usual number in the adult stage.

Horizon and localities. The cranidium, GSM. 35648, figured by Reed (1932, pl. 11, figs. 1, 1*a*) is labelled as coming from " Horderley Quarry ", but the state of preservation is such that it could only have been obtained from the *Onnia superba* Zone of the famous " Cliff Section " in the north bank of the River Onny, 720 yards west-south-west of Wistanstow Church. Of Reed's other specimens the figured pygidium GSM. 35641 (Reed, 1932, pl. 11, fig. 4) and the cited pygidium GSM. 35642 (Reed, 1932 : 208) are both labelled as deriving from the uppermost Caradoc beds of the River Onny, that is to say, the *Onnia superba* Zone. GSM. 35641 has the preservation characteristic of this horizon, but GSM. 35642 is more typical of material found in the mudstones of Actonian age which are well exposed in the bed and banks of the River Onny near the junction of Batch Gutter with the river. *Ampyxella edgelli* occurs in both the Actonian and Onnian Stages (upper part of the Zone of *Dicranograptus clingani*), but has not yet been recorded with certainty outside the general area of the Onny Valley in south Shropshire.

Lectotype (here selected). GSM. 35648 (Pl. 11, fig. 3).

Paratypes. GSM. 35641 ; GSM. 35644 ; GSM. 35646.

Figured Specimens. Sedg. Mus. A. 43831 (Pl. 11, fig. 1) ; Bristol University 8312 (Pl. 11, fig. 6) ; BM. In. 49724 (Pl. 11, fig. 4) ; BM. In. 37612 (Pl. 11, fig. 7).

Discussion. The pygidium and uncrushed cranidium of *Ampyxella edgelli* now figured bear a considerable resemblance to those described by Angelin (1854 : 81, pl. 40, figs. 5–5*c*) as *Ampyx? aculeatus*. The type cranidium of this species has been re-examined and figured by Thorslund (1940 : 153, pl. 9, figs. 10, 11) from the Upper *Chasmops* Limestone, Stage 4bδ, of Nakkholmen, near Oslo, but no whole individual has yet been described, and the pygidium is still imperfectly known. Until an entire specimen of this species becomes available no final decision can be made, but *Ampyxella edgelli* and *Ampyx*? *aculeatus* may prove eventually to be conspecific. The horizon of the Norwegian material corresponds broadly with that of the Shropshire specimens.

Genus ***LONCHODOMAS*** Angelin, 1854

TYPE-SPECIES. *Ampyx rostratus* Sars, 1835 by subsequent designation of Raymond (1925 : 30).

Lonchodomas pennatus (La Touche)

(Pl. 11, figs. 2, 5, 8–12)

1884. *Ampyx pennatus* La Touche, pl. 3, fig. 56.
1932. *Ampyx* (*Lonchodomas*) *pennatus* La Touche : Reed, p. 205, pl. 11, figs. 5–7.
1949. *Lonchodomas pennatus* (La Touche) Bancroft, p. 299, pl. 10, fig. 17.

The holotype, the first and only published figure of which was that given by La Touche, consists of a rather poorly-preserved cranidium, the glabella and fixed cheeks being present as an internal mould, and the underside of the frontal spine as an external mould. Reed's description (1932 : 205), founded mainly on material collected from the Onny Valley and now in the Geological Survey and Museum, gave an accurate picture of the cranidium but did not include sufficient details of the thorax, and was misleading with reference to the pygidium. A mature thorax now available (Pl. 11, fig. 8) shows the first of the thoracic segments to be slightly macropleural, the anterolateral edges running backwards and outwards from the fulcral processes to the backwardly-placed pleural ends. The equidimensional second and third segments form the widest part of the thorax which tapers hence both anteriorly and posteriorly. Apart from those of the first segment, all the pleural terminations are bluntly ended. The axis occupies roughly one-third of the total breadth, being separated from the pleural lobes by poorly-defined axial furrows. Each pleura is divided into a wide (*exsag.*) anterior band and a narrower (*exsag.*) posterior band by a pleural furrow which commences a short distance outside the axial furrow and runs outwards and slightly forwards to the pleural point, at the same time becoming deeper. The posterior margin of each axial ring is slightly convex forwards, so that a small part of the articulating half-ring of the succeeding segment is exposed.

The pygidium of the adult trilobite does not possess the angular outline described by Reed (1932 : 206) from a young specimen, and is semi-elliptical in plan, the breadth being about two and a half times the length. Reed's figure of a whole individual

(1932, pl. 11, fig. 7) is founded on a small specimen and it appears that the form of the pygidium changed during ontogeny. The axis stands higher than the pleural lobes into which it grades imperceptibly, the axial furrows being ill developed as on the thorax. Only one pair of pleural furrows is present and these follow the course of the pleural furrows of the thorax, starting just outside the axial furrows and becoming deeper until they attain the lateral margin. The border of the pygidium is steeply declined and carries terrace-lines ; the remainder of the test of both thorax and pygidium is smooth. One photograph (Pl. 11, fig. 11) was taken with the test of the pygidium wet so as to show the pygidial muscle-scars. There are eight visible pairs of large, sub-oval scars, each with its long axis directed outwards and backwards, situated just inwards from the axial furrows. Between each pair of conspicuous scars is another pair of smaller, fainter scars. Sometimes similar muscle-scars are also found, faintly-impressed, on the internal mould of the glabella (Pl. 11, fig. 5). All these muscle-scars correspond with those illustrated by Whittington (1950 : 556, text-fig. 7) for *Lonchodomas rostratus* (Sars), though the pygidium of the latter species shows only six pairs of large scars.

HORIZON AND LOCALITIES. The state of preservation of La Touche's holotype, as a limonitic mould in an ochreous-weathering mudstone, associated with " *Rafinesquina* " *holli* (Davidson), shows that the specimen must have been collected from the beds of the Onnian Stage, *Onnia superba* Zone, such as are exposed at the " Cliff Section " in the north bank of the River Onny 720 yards west-south-west of Wistanstow Church. In south Shropshire *Lonchodomas pennatus* appears first in the lowest beds of the Actonian Stage, and is not uncommon both there and in the succeeding *Onnia*? *cobboldi* and *Onnia gracilis* Zones, particularly the latter, of the Onnian. The species occurs also in the Onnian of the Cross Fell Inlier.

HOLOTYPE. BM. In. 37621 (Pl. 11, fig. 12).

OTHER SPECIMENS. BM. In. 48561 (Pl. 11, figs. 2, 5) ; BM. In. 48935 (Pl. 11, fig. 8) ; BM. In. 48934 (Pl. 11, figs. 9, 11) ; BM. In. 48939 (Pl. 11, fig. 10).

DISCUSSION. The specific name *pennatus* as applied to this form was originally used by Salter as an unpublished manuscript name for the species which is now known as *Ampyxella edgelli*. The Shropshire trilobite bears an obvious resemblance to *Lonchodomas rostratus* Sars sp. (Størmer, 1940 : 128, pl. 2, figs. 1–4) from the *Ampyx* Limestone, Zone of *Nemagraptus gracilis*, of the Oslo region, Norway, but the glabella of the latter species is slimmer with a slightly-developed median ridge or carina which diminishes posteriorly, and the pygidium is proportionately shorter with two pairs of pleural furrows instead of one.

The cranidium of *Lonchodomas politus* (Raymond, 1925 : 39, pl. 2, figs. 8–9 only ; Cooper, 1953 : 18, pl. 6, figs. 1, 2, 5–10), though possessing a test partly covered with coarse punctae, is generally similar to that of *L. pennatus*, but the pygidium of the North American species is noticeably different, being shorter and more distinctly segmented. *Lonchodomas punctatus* (Cooper, 1953 : 18, pl. 4, figs. 20, 21) possesses a pygidium which is very close, both in outline and segmentation, to that of *L. pennatus*, but as no other part of the exoskeleton has been figured it is not possible to make a detailed comparison. Both these North American forms are from the Black River Stage of Tennessee.

Family TRINUCLEIDAE Hawle & Corda, 1847

Until Bancroft's work on the separation of new genera of trinucleid trilobites the only names in general use were *Trinucleus*, *Cryptolithus* and *Tretaspis*, and some disagreement existed as to whether the first two of these were synonymous one with the other. Reed (1912, 1912*a*) disregarded to a large extent the pitting of the cephalic fringe, though discussing its structure, and stressed the form of the glabella and glabellar furrows. Bancroft (1929*a*) also considered these criteria, but emphasized the importance of the fringe pits in classification. In his work on the Scandinavian Trinucleidae Størmer (1930) rejected most of Bancroft's genera established on fringe characters but later (1945) partly retracted his criticisms, though only to the extent of accepting the names as possible sub-genera within *Cryptolithus*. Whittington (1940) refuted Størmer's contentions and followed Bancroft in stressing the importance of the form and pattern of the cephalic fringe. In a later paper (1941) he repeated this argument and, in a review of trinucleid classification, retained all the valid genera proposed by Bancroft ; *Ulricholithus* Bancroft, 1933 was at that time invalid and remained so until 1949. All the genera found in south Shropshire were placed in the subfamily Cryptolithinae, following Bancroft, but some of these forms differ so markedly from *Cryptolithus* (*s.s.*) in fringe pattern that the establishment of further subfamilies will probably be necessary, though the present state of knowledge is insufficient to attempt this satisfactorily.

More recently Whittard (1955 ; 1956 ; 1958) has followed the lines of attack set out by Bancroft and erected several new trinucleid genera, all of pre-Caradoc age, which, like the south Shropshire forms, have proved to be of great stratigraphical value. He has also proposed a modified form of Bancroft's notation for the fringe pattern whereby any particular pit can now be represented by a formula. Whilst this has proved particularly useful in the case of earlier Ordovician Trinucleidae with a simpler pit arrangement, it is often more difficult to apply it to all Caradoc forms with equal success owing to the more elaborate pattern, and in certain cases it has been found convenient to return to what is virtually Bancroft's original method.

Any modern account of trinucleid trilobites must consider not only the arrangement and relative size of the pits of the cephalic fringe as well as the position of the girder, but also other factors such as the outline and form of the cephalon, the form of the glabella and glabellar furrows, the type of pygidium, and the occasional presence of raised ridges between radial rows of pits. Whittard (1958 : 84) has questioned the validity of the last of these features, claiming that such interradial ridges may be the result of a different environment, but this argument lacks conviction as the ridges have been found to persist in certain species of *Broeggerolithus* preserved in mudstone, limestone and sandstone environments, and they are useful for at least specific discrimination. Their development can be traced in *Broeggerolithus*, in which they appear markedly for the first time.

The reticulation of the test in trinucleids has been accepted as a feature of importance by Bancroft (1933 : 2 ; 1949 : 295) ; he used its absence as one of the diagnostic features of his genus *Ulricholithus* (here placed in the synonymy of *Broeg-*

gerolithus), and attributed its absence to the effects of a deep, muddy environment (1949 : 297). Further examination of the south Shropshire material shows that, generally speaking, most trinucleids bear reticulation on the surface of the glabella and cheeks during the early stages of their development, in both limestone and mudstone environments. This is usually apparent when the original test or its impression is preserved, but the reticulation may not survive the limonitic replacement of the test. In most cases it disappears by the time the adult stage of development is reached, but may sometimes be retained as, for example, in certain specimens of *Broeggerolithus longiceps* (Bancroft) and *B. transiens* (Bancroft). In one case a small holaspid of *Reuscholithus reuschi* Bancroft, 11 mm. broad, shows relict traces of reticulation, not only on the posterior part of the cephalon but also on the thoracic segments. Rarely a single slab of rock may contain specimens of one species, apparently at the same stage of development, of which one has a smooth test whilst another adjacent to it has reticulate cheek-lobes and glabella.

Størmer (1930) published graphs showing the variation in the number of pits present at different points of the cephalon in certain Trinucleidae, particularly *Tretaspis*; the pits included were *a.* those along the rear margin of the fringe, *b.* the number of rows in front of the glabella at its mid-point, and *c.* the number of rows in front of the axial furrows. The range of variation, especially of *b.* and *c.* was not usually very great. More recently Cave (1957) has shown the greater variation in the number of fringe pits present in the species *Salterolithus caractaci* (Murchison) at one horizon in the Caradoc Series of Welshpool. In the present work an attempt has been made to indicate the variation in the number of pits found in certain species from Shropshire, but this has only been attempted in cases where the number of specimens is considered sufficiently large.

In spite of the criticism engendered by Bancroft's " splitting " of the Trinucleidae into numerous genera, it becomes obvious after examination of large-scale collections that the number of available generic names is not yet sufficient, and that at least one more must be erected to contain only those species found in the Caradoc Series of south Shropshire. The question of the relationships of the Trinucleidae is complex, and will not be made easier by attempting to extend the scope of existing genera beyond reasonable limits, such a course tending to suggest close affinities which may not, in fact, exist. In the present work the following genera are recognized :

Costonia Whittard, 1956. Type-species : *Marrolithus ultimus* Bancroft, 1949. Geological range : uppermost Costonian. Distribution : known only from south Shropshire.

Reuscholithus Bancroft, 1929. Type-species : *Reuscholithus reuschi* Bancroft, 1929. Geological range : lowest Harnagian. Distribution : known only from south Shropshire.

Smeathenia gen. nov. Type-species : *Salterolithus smeathenensis* Bancroft, 1949. A detailed description and diagnosis will be found later in this paper. Geological range : lowest Harnagian. Distribution : known only from the southern part of the Caradoc Area, south Shropshire.

Salterolithus Bancroft, 1929. Type-species : *Trinucleus caractaci* Murchison, 1839. Geological range and distribution : in south Shropshire the genus appears early in the Harnagian Stage, and ranges upwards into the *Broeggerolithus broeggeri* Zone of the Soudleyan. A similar range is known from the Shelve Inlier, the Welshpool District and, perhaps, Central Wales.

Broeggerolithus Lamont, 1935 *ex* Bancroft MS. Type-species: *Cryptolithus broeggeri* Bancroft, 1929. As already stated, *Ulricholithus* Bancroft, 1949 (type-species: *Salterolithus* (*Ulricholithus*) *ulrichi* Bancroft, 1949) is considered here to be synonymous with *Broeggerolithus*, thus necessitating a slight modification of the definition of the lower limit of the Soudleyan Stage (see page 000). Geological range: the appearance of *Broeggerolithus* was thought to indicate the beginning of the Soudleyan Stage, but the species originally described as *Salterolithus harnagensis* Bancroft, from the lowest zone of the Harnagian, is here interpreted as being a primitive member of *Broeggerolithus*, possibly linked to the typical *B. broeggeri* by forms such as *Broeggerolithus* [*Ulricholithus*] *ulrichi* (Bancroft). The genus ranges through at least to the end of the Marshbrookian, but evidence of its existence in the Actonian, either in south Shropshire or the Cross Fell Inlier, is not yet satisfactorily established. One of the most abundant and widespread of all trinucleid genera *Broeggerolithus* is known from south and west Shropshire, most parts of North Wales, Central Wales, the Cross Fell Inlier, the Dry Gill area of the northern Lake District, and perhaps also southern Norway and Sweden.

Onnia Bancroft, 1933. Type-species: *Cryptolithus superbus* Bancroft, 1929. Geological range and distribution: in the Anglo-Welsh area the genus is confined to the Onnian Stage of south Shropshire, the Welshpool district and the Cross Fell Inlier, but may occur slightly later in southern Norway. A record of *Onnia* from Venezuela is certainly incorrect, but the genus occurs abundantly in European Middle Ordovician faunas of Bohemian affinities.

Genus *COSTONIA* Whittard, 1956

DIAGNOSIS: Cephalon with sub-rounded anterolateral angles. Fringe carries one row of pits external to the girder, except in front of the glabella, where there may be up to twelve adventitious pits, forming what is virtually the beginning of an E_2 row. The pits of E_1 become distended at the anterolateral angles in the adult form. Pygidium is short, with curved posterior margin, and the segments of the pleural lobes are poorly defined.

DISCUSSION. The genus was erected by Whittard to include those *Marrolithus*-like trinucleids in which an E_2 row of up to about twelve pits is developed in front of the glabella. *Costonia* appears to be restricted in its vertical range to the topmost beds of the Costonian Stage where it constitutes a useful zonal index. The genus is not yet known outside south Shropshire where *Costonia ultima* (Bancroft) and *C. elegans* sp. nov. are apparently characteristic of the southern and northern parts respectively of the Caradoc Area; these districts correspond, at least in a general way, with those portions of the type Caradoc Series which crop out to the south and north of the Cardington Hills, east of Church Stretton.

TYPE-SPECIES. *Marrolithus ultimus* Bancroft, 1949 by original designation of Whittard (1956: 50).

Costonia ultima (Bancroft)

(Pl. 12, figs. 1–12)

1949. *Marrolithus ultimus* Bancroft, p. 297, pl. 9, fig. 7.
1956. *Costonia ultima* (Bancroft) Whittard, p. 50.
1958. *Costonia ultima* (Bancroft) : Dean, pl. 26, figs. 1, 2.

Bancroft's holotype, In. 43489 (Pl. 12, fig. 10), is a fragment, rather less than half, of the external mould of a cephalon estimated to have been about 7 to 8 mm. in length, and was figured in the form of a gutta-percha cast. The specimen does not show the development of E_2 pits characteristic of the genus, and though the pygidium was described briefly it was not figured, nor was any specimen in the Bancroft Collection singled out as type-material. Well-preserved topotypes are not easy to obtain, and the following detailed description is founded on mainly fragmentary specimens collected from decalcified massive sandstones.

The complete exoskeleton, excluding the genal spines, is slightly longer than wide. In one such example the maximum breadth of the cephalon is 17 mm. and the total length, including thorax and pygidium only, is 19 mm.; the overall length of the same entire specimen, including the broken-off genal spines, is at least 21 mm. The cephalon is almost subrectangular in outline and moderately convex, its length, excluding the occipital spine and genal spines, being rather more than half the maximum breadth. The glabella is long, moderately convex and tapering posteriorly, standing higher and extending forwards farther than the plump cheek-lobes. The axial furrows are deep and broad, slightly convex outwards, with small hypostomal pits situated anteriorly. In some internal moulds a pair of poorly-defined glabellar furrows is seen delimiting a pair of small, basal glabellar lobes. The occipital furrow is shallow and transversely straight, ending laterally in a pair of slot-like apodemal pits ; the occipital ring is short (*sag.*) and produced into an inclined occipital spine, the combined length of the two being just over half that of the glabella. The pleuroccipital furrow is straight and moderately deep, marking-off the narrow (*exsag.*) posterior border which continues transversely straight as far as the fulcral sockets where it is turned backwards slightly towards the genal angles. The cephalic fringe is declined gently in front of the glabella and more steeply at the sides ; the posterolateral portions of the lower lamella of the fringe are produced into long genal spines, each prismatic and longitudinally grooved, which are noticeably splayed. The median part of the frontal margin is slightly convex forwards, resulting in a bluntly-pointed appearance, the lateral margins are slightly convergent forwards, and the anterolateral portions of the fringe are moderately obtuse. There are four concentric rows of pits present in front of the glabella, of which the outermost, E_2, consists merely of eight to twelve pits arranged in such an irregular manner that they cannot satisfactorily be placed in the fringe formula. Usually E_2 extends on either side of the sagittal line as far as R4 or R5. The remainder of the fringe formula of an average cephalon is E_1 1–23 or 24 ; e_1 xix ; I_1 1–25, I_2 1–21 (beyond which point the radial arrangement ceases), I_3 3 or 4–24, I_4 6 or 7–24. Over much of the fringe both concentric and radial arrangement of pits is conspicuous, but beyond R19 to R21 the radial arrangement is continued only in I_1 and E_1. The pits of I_1 and I_2 are almost equal in size, and larger than those of other rows; in some specimens there may be some inflation of the fringe centred on pits I_1 12–15 or 16. There are usually 10 or 11 pits situated along the posterior fringe margin which is directed outwards and slightly backwards, and is gently convex posteriorly. No well-preserved specimen has yet been found showing the underside of the fringe, but external moulds indicate that the girder is not particularly well developed, though becoming stronger just before reaching the genal angle. There is a pseudogirder between I_3 and I_4, which are farther apart than the other concentric rows, but it is only developed in the anterolateral parts of the fringe (Pl. 2, figs. 2, 5).

The thorax consists of six segments of typical trinucleid form, the first being macropleural with its anterolateral edges running sharply backwards and outwards from the fulcral processes to the pleural points. The axis of each segment, standing only slightly higher than the side lobes, occupies roughly one-quarter of the total breadth, and, in the internal mould, has two pairs of apodemal pits. The first and larger pits are situated in the articulating furrow just inwards from the axial furrows; the second pair is situated slightly to the rear of the first, in the axial furrows themselves and just in front of the posterior margin of the segment. Each pleura carries a pleural furrow which runs outwards and slightly backwards from just outside the axial furrow to the backwardly-directed pleural point, at the same time becoming noticeably deeper. Each pleural furrow divides the pleura into a posterior and an anterior band, of which the former is the wider (*exsag.*).

The pygidium is semi-elliptical in plan, the breadth about three times the length. There is a slightly-raised marginal ridge, and the border is steeply declined. The axis is better defined in the internal than in the external mould, occupying between one-quarter and one-fifth of the maximum breadth and carrying one axial ring. The axial furrows are poorly defined on the external mould, and the side-lobes are almost smooth, but there is a suggestion of two pairs of pleural furrows near the lateral margins.

HORIZON AND LOCALITIES. The type-locality is the disused quarry about 500 feet south of Coston farmhouse, one mile east of Clunbury, but the species also occurs abundantly at the old quarry in Brokenstones Plantation 1600 yards north-east of Horderley Station. *Costonia ultima* has also been found at the small quarry by the east side of the barn 400 yards north of Glenburrell Farm, Horderley, and at the now overgrown quarry 650 yards west of Woolston House, Woolston. All these localities are in the topmost part of the Costonian Stage of the southern Caradoc Area, in strata to which the names *Horderleyella plicata* Zone, Upper Coston Beds and *Costonia ultima* Beds have variously been applied (Dean, 1958 : 197).

HOLOTYPE. BM. In. 43489 (Pl. 12, fig. 10).

OTHER SPECIMENS. BM. In. 54031 (Pl. 12, figs. 1, 3); BM. In. 48942 (Pl. 12, fig. 4); BM. In. 54033 (Pl. 12, fig. 7); BM. In. 54036 (Pl. 12, figs. 2, 5); BM. In. 48940 (Pl. 12, fig. 8); BM. In. 54032 (Pl. 12, fig. 9); BM. In. 54034 (Pl. 12, fig. 11); BM. In. 48941 (Pl. 12, fig. 12); BM. In. 54035 (Pl. 12, fig. 6).

DISCUSSION. Apparently Bancroft named his species *Marrolithus ultimus* in the belief that he was, in fact, dealing with the last known form of *Marrolithus*, and in his Correlation Tables (1933 : Table 3) he equated the Spy Wood Grit with the Hoar Edge Grit of the Caradoc Area on the grounds that it contained what he called " *Marrolithus* (Costonian type) ". However, Whittard (1955 : 5 ; 1956 : 60–63) has shown more recently that the Spy Wood Grit belongs to the *Diplograptus multidens* Zone, so that it must therefore be younger than the Costonian, and that all the trinucleids known from the horizon may be referred to *Marrolithus* (*s.s.*). None of these species bears any resemblance to *Costonia* which is easily distinguished by its anterior development of E_2 pits and which, so far as is now known, is restricted to the Caradoc Area.

Costonia elegans sp. nov.

(Pl. 13, figs. 1–6, 8, 9)

1938. *Trinucleus* (*Cryptolithus*) aff. *favus* Salter : Stubblefield *in* Pocock *et al.*, p. 256.
1956. *Costonia* sp. nov. Dean *in* Whittard, p. 50.
1958. *Costonia* sp. nov. Dean, pp. 198, 218.

DESCRIPTION. The cephalon is moderately convex longitudinally and strongly convex transversely, its length, excluding genal spines, being about two-thirds of the breadth. The anterior border is gently convex, particularly medially, and the lateral margins are straight and convergent anteriorly. The glabella is moderately convex, with a small median ocellus, and extends slightly forwards in front of the cheek lobes, from which it is separated by broad, shallow axial furrows containing small hypostomal pits. Glabellar furrows are present only as two, or perhaps three, pairs of poorly-defined depressions which probably represent the position of muscle-scars. The occipital ring is transversely convex, and produced into a stout occipital spine directed upwards and backwards. The pleuroccipital furrows and pleuroccipital segment are markedly straight transversely as far as the fulcral sockets, but beyond these the posterior margin curves strongly backwards and then outwards to the genal angles. The test is frequently preserved and, in the adult, quite smooth, though a fragment of the cheek-lobe of a small individual (Pl. 13, fig. 9), estimated breadth about 5 mm., is strongly reticulate. In front of the glabella the fringe is moderately declined, becoming almost flat near the anterior border ; the lateral portions of the fringe are steeply declined. There are four continuous rows of pits, E_1 and I_{1-3}, and E_2 is developed to the extent of up to a total of 18 pits which may extend as far as R9 on either side of the sagittal line. E_1 consists of 34 small pits in the holotype, but I_1 comprises 23 larger pits, including a number of inflated ones at the anterolateral angles. The pits of I_2 and I_3 are small, numbering 26 and 22 respectively, whilst I_4 consists of 20 pits of similar size and extends from R5 or the line of the axial furrow. The 20 pits of I_5 are smaller, developed only from R6 or R7, and I_6 includes only 6 or 7 pits at the posterolateral angle of the cheek-lobe. Many of the pits have a conspicuous radial arrangement, and nineteen radii can be counted but beyond this point numerous auxiliary pits are added and the radial pattern is lost in a complex of pits. The notation for the principal rows of the fringe of the holotype, as far as the radial pattern persists, is E_1 1–20 ; E_2 1–7, 9 ; e_1 ii, iv, v, viii, ix, xiii ; e_2 0, i, iii ; I_1 1–21 ; I_2 1–22 ; I_3 4–22 ; i_2 vi, xix ; i_3 x. The area of inflated pits at the anterolateral angles is restricted in comparison with that usually found developed in *Marrolithus* (*s.s.*), and includes only pits of I_1 ; according to the notation proposed by Williams (1948 : 68–70) the inflated area is represented by the formula $CA71_1$, but using the more generally applicable method of Whittard this becomes I_1 10–16. The genal spines are not completely known but appear to curve outwards and backwards from the genal angles ; they arise in advance of the rearmost part of the posterior margin, which is strongly convex posteriorly and forms fairly large " ears ".

The thorax is unknown.

The pygidium is bluntly pointed posteriorly, the posterolateral margins being gently curved or slightly subangular. The breadth is roughly three times the length, and the border is steeply declined for the most part, becoming less so at the posterior termination. The axis is narrow, about one-sixth of the total breadth, and the axial rings number about 10 or 11 ; the first six ring furrows are continued on to the generally flat side-lobes as six fairly well-defined pleural furrows which become slightly sigmoidal towards the margins.

Comparatively little is known of the development of *Costonia elegans*, but no anterolateral development of inflated pits in I_1 has yet been found in cephala up to 12 mm. in breadth. As stated earlier, a fragment of an immature cheek-lobe, in common with those of numerous other Trinucleidae, shows reticulation which disappears by the time the adult stage is reached.

HORIZON AND LOCALITIES. The species occurs fairly abundantly at one horizon, the sandy limestones with *Harknessella subquadrata* Bancroft which constitute the topmost local subdivision of the Costonian throughout the northern part of the Caradoc Area of south Shropshire. *C. elegans* has not yet been found outside the northern Caradoc Area, and the strata for which it is the characteristic fossil are believed to be represented farther south by more arenaceous beds containing another species of *Costonia*, *C. ultima* (Bancroft). With the exception of one specimen, In. 49728, all the type material is from the old quarry in the north-eastern part of Round Nursery, 1,380 feet south-east of Harnage Grange, the remaining paratype being collected from the upper beds of the disused quarry at the eastern end of Black Dick's Coppice, Evenwood. The new species occurs also at the Bullhill " gutter-section ", Evenwood, and at the disused quarry in The Cwms, east of Church Stretton.

HOLOTYPE. BM. In. 49744 (Pl. 13, figs. 1, 2, 4).

PARATYPES. BM. In. 49733 (Pl. 13, fig. 3) ; BM. In. 49746 (Pl. 13, fig. 9) ; BM. In. 49747 (Pl. 13, fig. 6) ; BM. In. 49311 (Pl. 13, fig. 8) ; BM. In. 49745 (Pl. 13, fig. 5).

DISCUSSION. *Costonia elegans* differs from *C. ultima* (Bancroft), the only other described species of the genus, in having a greater development of E_2 in front of the glabella and a much larger number of pits with a random arrangement at and near the genal flanges, in the conspicuous rearward convexity of the posterior margin of the fringe, and in the less rounded outline of the pygidium. Our knowledge of the last of these is established as yet, however, only on immature material, and it is possible that the outline of the pygidium may change during ontogeny. The new species is important in that it appears to mark a transition, both morphological and stratigraphical, between the genera *Marrolithus* and *Reuscholithus*. The inflated anterolateral areas of the fringe are particularly characteristic of *Marrolithus*, but the outline of the cephalon, the forward position of the genal spines and the numerous random pits are more typical of *Reuscholithus*.

Genus ***REUSCHOLITHUS*** Bancroft, 1929

This so far mono-specific genus is confined to the lowest trilobite-zone, to which it gives its name, of the Harnagian Stage in south Shropshire, and has not yet been found outside the Caradoc Area.

TYPE-SPECIES. *Reuscholithus reuschi* by original designation of Bancroft (1929*a* : 78).

Reuscholithus reuschi Bancroft

(Pl. 14, figs. 1–14)

1929*a*. *Reuscholithus reuschi* Bancroft, p. 82, pl. 1, figs. 3–5.
1938. *Trinucleus* (*Cryptolithus*) *reuschi* (Bancroft) Stubblefield *in* Pocock *et al.*, p. 256.
1949. *Reuscholithus reuschi* Bancroft : Bancroft, p. 297, pl. 9, fig. 3.
1958. *Reuscholithus reuschi* Bancroft : Dean, pl. 26, fig. 3.

DESCRIPTION. The cephalon is moderately convex, bluntly rounded to broadly pointed in front. The anterolateral margins may be subangular or rounded, the straight sides being slightly convergent anteriorly. Generally speaking, the ratio of length to breadth for the cephalon varies according to the stage of development reached by the individual, the length becoming proportionately greater with increase in size, as shown by the accompanying data :

Specimen Number	Cephalic Breadth (mm.)	Length/Breadth (as %)
In. 50688	7·0	37
In. 49317	7·5	40
In. 50518	10·0	40
In. 52844	13·5	41
In. 50517	17·0	41
In. 42080	22·0	45

Certain exceptions to this generalization are known, but most, and perhaps all, of them are due to crushing.

The glabella is slightly clavate anteriorly and, in immature individuals, usually carries a median ocellus which is absent from the largest specimens. Glabellar furrows may often be found represented by two pairs of shallow ovoid impressions situated just inwards from the moderately deep axial furrows in the posterior half of the glabella. Hypostomal pits are poorly developed. Each cheek lobe is about as wide as long in the adult, and only moderately convex ; in young individuals the surface is coarsely reticulate, but is smooth by the time the adult stage is reached.

A shallow occipital furrow which deepens laterally demarcates the occipital ring which is produced into a small occipital spine directed backwards and upwards.

The fringe is gently declined frontally and laterally when uncrushed, the surface of the upper lamella being flat, and the pits are often polygonal rather than circular in form, especially at and near the genal flange. The concentric rows E_{1-2} and I_{1-3} are continuous in front of the glabella, and I_4 is almost continuous, extending as far forwards as R3 or R4. The pits of I_{1-3}, especially I_{2-3}, are larger than those of neighbouring rows. The most conspicuous features of *Reuscholithus reuschi* are the complexity and irregularity of the pitting of the fringe, making the application of the usual notation impracticable. Usually the radial arrangement is particularly persistent in I_{1-5}, but beyond a point which may vary from R19 to R22 the pits form a more or less random complex. At and near the anterolateral angles only E_1 occurs outside the girder, though usually with several auxiliary pits, but in front of the glabella pits of E_2 extend as far as R10 or R11, and often there are several adventitious pits situated so as to form a quincuncial pattern with those of E_1 and E_2. Towards the genal angles E_2 is often represented only by occasional adventitious pits, and in the same portion of the fringe E_1 contains numerous small pits, but in some immature individuals E_2 is fairly well developed to the extent of seven or more pits. The holotype (Pl. 14, figs. 1, 3) is one of the largest-known individuals and differs from the more typical forms of the species in the small outward displacement of the pits of E_2, which may occasionally form twin-pits with those of E_1. In the same specimen E_1 contains numerous small pits, only a few of which fall out of line towards the genal angle, so that it is difficult to distinguish any representative of E_2 in that region. The pleuroccipital furrow and segment are transversely straight, but beyond the fulcral sockets the posterior margins of the fringe are convex and extend rearwards to form well-marked " ears ", a feature best shown in the adult trilobite. The holotype has an estimated twelve small pits along the posterior margin of the fringe. Although Bancroft (1929*a* : 83) described the girder as ill-defined, in fact the underside of the fringe carries a usually well-defined girder which becomes stronger medially (see Pl. 14, fig. 9). In young individuals the position of the girder is marked on the upper lamella of the fringe by a smooth concentric " band ", but such a feature is not found in the adult. The fringe perimeter has a small, narrow, raised marginal band and there is a marginal suture of typical trinucleid type. The lower lamella of the fringe is produced posterolaterally into grooved genal spines which curve gently outwards and then inwards. No adult *R. reuschi* has yet been found with the spines entire, but in some immature individuals they are known to extend well beyond the tip of the pygidium.

The thorax consists of six segments of normal trinucleid type, the first macropleural, with the axis occupying about one-fifth of the total breadth. Each axial ring is curved forwards both medially and laterally, and carries a pair of apodemes. The pleurae are flat, each with a broad (*exsag.*), shallow furrow which commences near the anterior margin at the axial furrow and runs outwards and backwards to the blunt, backwardly-directed pleural point. In the case of one specimen (Pl. 14, fig. 4) the faint reticulation just discernible on parts of the cephalon is also found, though still further diminished, on the pleurae.

The pygidium is semi-elliptical in outline, its breadth about four times the length, with a steeply-declined border and a small, raised marginal rim inside of which runs a parallel, broad (*exsag.*), shallow sulcus, giving the pleural lobes a slightly swollen appearance. The axis is small, about one-sixth of the total breadth; it tapers sharply rearwards and attains the posterior margin. There are two axial rings, and faint suggestions of others. Each pleural lobe carries six pleural furrows which diminish in strength both posteriorly and laterally; the first two or three pleurae have faintly-marked rib furrows.

IMMATURE INDIVIDUALS. In his original description of the species Bancroft (1929*a* : 83) drew attention to the number of immature specimens found in the *Reuscholithus reuschi* Zone of Coundmoor Brook but as most of these are disarticulated fragments it has not proved possible to work out the ontogeny satisfactorily, though the development of the cephalon is fairly well known.

The smallest specimen (Pl. 14, fig. 11), possibly that referred to by Bancroft (1929*a* : 83), is a poorly-preserved cephalon with two attached thoracic segments. The fringe is incompletely preserved, but shows three concentric rows of pits with a strong radial arrangement; the breadth is just less than 2·5 mm. and the length about 0·8 mm. This specimen possesses also a pair of occipital pits and two pairs of deep glabellar furrows.

Perhaps the most conspicuous feature of the cephalon of *R. reuschi* is the manner in which the posterior margin of the fringe in immature individuals projects backwards slightly at the fulcral sockets and then, beyond them, curves forwards towards the genal angles which, at their farthest forward position, are situated just behind the line of the median ocellus on the glabella. As development proceeds, the position of the genal angles moves progressively rearwards until in the adult they are situated behind the line of the pleuroccipital furrow, at the tips of the "ears" already mentioned.

All the smallest specimens available possess cheeks and, to a lesser extent, glabella with a coarsely reticulate surface, a median ocellus on the glabella, long alar lobes diverging slightly forwards (see Pl. 14, figs. 6, 10), and well-defined ocular ridges. The last-named join the sides of the glabella approximately in line with the median ocellus, then are directed outwards and slightly backwards to extend through, and a short distance beyond, the axial furrows, and finally terminate in small ocelli. The smallest known specimen, mentioned above, shows traces of branching nervures extending laterally across the cheeks from the ocelli almost to the fringe. During subsequent growth the ocular ridges and ocelli disappear, and in specimens of Meraspis Degree 5 (Pl. 14, fig. 10) with a cephalic breadth of about 5 mm. they are absent, though alar lobes are still well developed. In his description of *Reuscholithus reuschi* Bancroft (1929*a* : 85, text-figs. 4*a*, *b*) gave diagrams purporting to show the early developmental stages, but in his figures the ocular ridges are too long (*tr.*) and the alar lobes are too short and round, lacking the elongate form actually found. One cephalon 7 mm. broad (Pl. 14, fig. 12), probably a young Holaspis, shows neither ocular ridges and ocelli nor alar lobes, but the cheek-lobes retain their coarse reticulation and the glabella its median ocellus. Traces only of fine reticulation have been found in a presumed holaspid cephalon 11 mm. wide (Pl. 14, fig. 4), and the largest known cephalon with a median ocellus is about 16 mm. (estimated) wide (Pl. 14, fig. 7). In common with certain other Trinucleidae the pattern of pit-arrangement appears to have become stable very early during ontogeny, development proceeding mainly by the addition of pits to rows already established. Bancroft's observations (1929*a* : 84) that E_1 and E_2 were formed early, and that subsequent development was essentially the addition of pits to the region internal to the girder, appear to be correct.

HORIZON AND LOCALITIES. The holotype was collected from the old cartway near the south-eastern corner of Smeathen Wood, Horderley, where the species occurs uncommonly in yellow, sandy mudstones, the Smeathen Wood Beds, associated with *Smeathenia smeathenensis* (Bancroft), *Phacopidina harnagensis* Bancroft, *Salopia salteri* (Davidson) and *Smeathenella harnagensis* Bancroft. In the Cressage District the principal localities are in Coundmoor Brook, *a.* by the north bank about 1300 yards south-west of Harnage Farm, *b.* by the north bank 1310 yards south-west of Harnage Farm, and *c.* in the south bank about 85 yards east-north-east of the north-eastern end of the large disused quarry near Stevenshill, but the species may be expected to be found at numerous other places in the vicinity where the Harnage Shales crop out, particularly in Coundmoor Brook immediately west of Coundmoor itself. Elsewhere *R. reuschi* has been found at localities along the small stream running between Gutter Cottage and Wallsbank Farm, east-north-east of Hope Bowdler. Owing to the unsuitability of the environment no larval forms have been found at the type-locality, and all such specimens described are from the Cressage and Wallsbank districts.

HOLOTYPE. BM. In. 42080 *a, b*. An incomplete cephalon first figured by Bancroft (1929*a* : pl. 1, fig. 3) and here refigured (Pl. 14, figs. 1, 3).

PARATYPES. The pygidium figured by Bancroft (1929*a* : pl. 1, fig. 4) has not yet been found, and it has not proved possible to trace with certainty the original of his schematic diagrams (1929*a* : pl. 1, figs. 5*a, b*).

OTHER SPECIMENS. BM. In. 50688 (Pl. 14, fig. 2); BM. In. 51501 (Pl. 14, fig. 4); BM. In. 50671 (Pl. 14, fig. 5); BM. In. 54028 (Pl. 14, fig. 6); BM. In. 50517 (Pl. 14, fig. 7); BM. In. 50519 (Pl. 14, fig. 8); BM. In. 49316 (Pl. 14, fig. 9); BM. In. 50665 (Pl. 14, fig. 10); BM. In. 50667 (Pl. 14, fig. 11); BM. In. 49317 (Pl. 14, fig. 12); BM. In. 50668 (Pl. 14, fig. 13); BM. In. 50672 (Pl. 14, fig. 14).

DISCUSSION. The irregular nature of the pitting of the fringe of *Reuscholithus reuschi* makes it unlikely to be confused with any other trinucleid. Bancroft (1935 : 333) derived *Reuscholithus* from *Marrolithus*, and it now appears highly likely that in *Costonia* we have a transition, both morphological and stratigraphical, between the two genera. *R. reuschi* bears a particularly noticeable resemblance to *Costonia elegans*, but may easily be distinguished by the total absence of inflated pits in E_1, by the development of E_2 both anteriorly and posterolaterally, and by the much more random distribution of pits generally. Nothing else comparable with *R. reuschi* is known, and Størmer's inclusion (1930 : 40) of the Shropshire species in the synonymy of what he called *Cryptolithus dicors* [*sic*] Angelin sp., a form which probably belongs to *Broeggerolithus*, is certainly incorrect.

Genus **SALTEROLITHUS** Bancroft, 1929

The generic name *Edgellia* was proposed by Shaw (*in* Shaw & Stubblefield, 1950 : 624) for *Trinucleus fimbriatus* Murchison, 1839, in the belief that the type-species of *Trinucleus* was *T. caractaci*. However, as Vogdes (1890 : 84) had already selected *T. fimbriatus* as the type-species of *Trinucleus*, *Edgellia* became an objective synonym of *Trinucleus* thus leaving *Salterolithus* Bancroft unaffected and available for use. *Salterolithus caractaci* has already been described in detail by both Cave (1957) and Whittard (1958) but, as the latter author has pointed out, Bancroft has at various times assigned to the genus trilobites with fringes which differ markedly from that of the type-species. These are listed below, together with the writer's interpretation of them.

a. Salterolithus harnagensis Bancroft (1929*a* : 79, pl. 1, fig. 1), from the basal Harnagian Stage of the Cressage district. No pits external to E_2. Similarly *Salterolithus* aff. *harnagensis* Bancroft from the basal Harnagian deposits forming Neptunian dykes at Hazler Hill, east of Church Stretton (Bancroft, 1949 : 291, pl. 10, fig. 15).

b. Salterolithus harnagensis Bancroft var. from " immediately above the Hoar Edge Grits " (Bancroft, 1929*a* : 80). Incipient E_3 developed by the division of E_2.

c. Salterolithus sp. E_3 well developed. Said to be an associate of *Salterolithus harnagensis*, and particularly characteristic of an horizon which Bancroft (1929*a* : 81) described as existing " between the *S. harnagensis* and *Reuscholithus reuschi* Zones ".

d. Salterolithus cf. *intermedius* (Wade) from " the lower 30 feet of the Harnage Shales at Horderley " (Bancroft, 1929*a* : 82). E_{3-4} well developed.

e. Salterolithus smeathenensis Bancroft (1949 : 292, pl. 9, figs. 1, 2, 2*a*) from the basal Harnagian near Horderley. E_{3-4} well developed, small development of E_5.

A reference by Bancroft (1949 : 293) to E_5 in a later description of *Salterolithus caractaci* is thought by Whittard (1958 : 84) to be possibly a misprint. Of the fringe-types listed above, that of group *a.* is, as suggested by Whittard (1958 : 83), probably best included in the genus *Broeggerolithus*, though this is a broad interpretation. The so-called *Salterolithus harnagensis* lacks certain features of the typical species of *Broeggerolithus*, and can probably be regarded as a primitive member of the genus. The form listed above in group *b.* has not yet been traced with certainty, but may also belong to *Broeggerolithus* (*s.l.*).

The *Salterolithus* sp. of group *c.* is thought to be a true member of the genus, and is almost certainly that described in the present paper as *Salterolithus praecursor* sp. nov. The species in group *d.* is without doubt the same as that described later as *Salterolithus smeathenensis* Bancroft, a species which comprises also group *e.* and is made the type of a new genus *Smeathenia* elsewhere in this paper.

DISTRIBUTION. In south Shropshire the first known occurrence of *Salterolithus* (*s.s.*) is in the shales and mudstones of the *Reuscholithus reuschi* Zone at Coundmoor Brook, near Cressage, just above the basal sandy beds of the Harnagian Stage. In the south of the Caradoc Area the genus does not appear until slightly later, in the *Salterolithus caractaci* Zone of the Harnagian. No definite records exist for the

Broeggerolithus ulrichi Zone, though this is likely to be due to the general paucity of fossils at the horizon rather than to actual absence, for *Salterolithus caractaci* itself is found, though not commonly, in the Lower Soudleyan, the last-known occurrence of both genus and species.

These records of *Salterolithus* in south Shropshire correspond in a general way with the limits of the *Diplograptus multidens* Zone as now interpreted there. Outside the Caradoc Area the genus occurs in the Soudleyan of the Pontesford District, the Harnagian and Soudleyan of the Shelve Inlier, the Harnagian of the Welshpool District, and is also known from the Breidden Hills, the Bala District, and the Dinas Mawddwy District of Merioneth (Pugh, 1928 : 351).

TYPE-SPECIES. *Trinucleus caractaci* Murchison, 1839 by original designation of Bancroft (1929*a* : 78).

Salterolithus caractaci (Murchison)

(Pl. 15, figs. 1, 2, 4, 6 and 9)

1839. *Trinucleus caractaci* Murchison, pp. 303, 650, 659, pl. 23, figs. 1*a–c* only.
1853. *Trinucleus concentricus* (Eaton) : Salter, pp. 3, 5.
1854. *Trinucleus concentricus* (Eaton) : Murchison, p. 203, pl. 4, figs. 2, 4, 5.
1859. *Trinucleus concentricus* (Eaton) : Murchison, p. 224, pl. 4, figs. 2, 4, 5.
1867. *Trinucleus concentricus* (Eaton) : Murchison, p. 204, pl. 4, figs. 2, 4, 5.
1872. *Trinucleus concentricus* (Eaton) : Murchison, p. 204, pl. 4, figs. 2, 4, 5.
1911. *Trinucleus intermedius* Wade, pp. 449–50, pl. 36, figs. 1, 2.
1911. *Trinucleus concentricus* var. *caractaci* Murchison, Wade, p. 424.
1913. *Trinucleus caractaci* Murchison : Raymond, p. 4.
1913*a*. *Cryptolithus caractaci* (Murchison) Raymond, pp. 28, 30.
1927. *Cryptolithus caractaci* (Murchison) : Stetson, pp. 89, 95.
1928. *Trinucleus caractaci* (Murchison) : Pugh, pp. 351–353, 375, 379.
1929*a*. *Salterolithus caractaci* (Murchison) Bancroft, pp. 74, 78, 82.
1933. *Salterolithus caractaci* (Murchison) : Bancroft, table 3.
1941. *Salterolithus caractaci* (Murchison) : Whittington, p. 25.
1949. *Salterolithus caractaci* (Murchison) : Bancroft, pp. 293–4.
1950. *Trinucleus caractaci* Murchison : Shaw & Stubblefield, p. 624.
1957. *Salterolithus caractaci* (Murchison) : Cave, p. 284, pl. 10, figs. 3–6.
1958. *Salterolithus caractaci* (Murchison) : Whittard, p. 85, pl. 12, figs. 2–6.
1958. *Salterolithus caractaci* (Murchison) : Dean, p. 201, pl. 26, fig. 5.
1958. *Salterolithus* sp. nov., Dean, p. 203.

The species was erected by Murchison (1839 : 659, pl. 23, figs. 1*a–f*) using six syntypes, four of which were figured and all of which he claimed were from " a little dingle west of Welch Pool Church ", a place known to geologists as " Trilobite Dingle ". These specimens are in the Geological Society Collection at the Geological Survey and Museum, and are numbered 6828–6832, 6834. Of the syntypes, 6828, 6833 and 6834 are labelled as being from Welshpool, and 6830 forms part of a block of grey mudstone from Wistanstow, written as Wistantow [*sic*]. The remaining specimen 6829 is not labelled, but according to the original register it, too, is from Wistanstow. Recently Cave (1957 : 284) has selected as lectotype specimen 6829 on the grounds that it agrees best with the mode of the population as established by him on a statistical basis for *S. caractaci* in the Welshpool district, and that it agrees lithologically with material from Trilobite Dingle (Bron-y-Buckley Wood), Welshpool. Whittard has expressed concern at this choice of lectotype (1958 : 83) owing to the apparent doubt regarding the original locality and the colour of the matrix, and would have preferred to choose specimen 6834, which is undoubtedly from Welshpool. The writer feels that these doubts are needless as Cave's lectotype agrees best with known Welshpool material from Trilobite Dingle ; it is certainly not from the Wistanstow district as stated in the Geological Survey register, and it seems likely that a mistake occurred in the original registration. The adjacent numbers refer to specimens which do, in fact, derive from near Wistanstow, and specimens 6830–6832, all on the same hand-specimen, are typical *Onnia superba* (Bancroft) from the Onny Valley. *Salterolithus caractaci* occurs in the middle Harnagian and Lower Soudleyan of the Onny Valley near Horderley, but there is no resemblance between the lithologies there and at Welshpool.

It is not proposed to describe *Salterolithus caractaci* in detail here in view of the very complete descriptions already available and noted above. Cave (1957 : 285) has given the following data for the outermost rows of fringe-pits : external to $E_1 = 35\text{–}79$, mode $= 58$; $E_1 = 26\text{–}29$, mode $= 27$; $I_1 = 23\text{–}28$, mode $= 25$ or 26. The specimens from the Harnagian of south Shropshire figured in this paper (Pl. 15, figs. 1, 2) have the following numbers of pits : external to $E_1 =$ about 58 ; $E_1 + e_1 = 26$; $I_1 + i_1 = 26$, and can thus be seen to conform extremely closely to the average member of the Welshpool population. Of the specimens collected from the Lower Soudleyan of the Onny Valley and assigned to *S. caractaci*, a typical individual, In. 51207, has the following pit-count : external to $E_1 = 59$; $E_1 + e_1 = 28$; $I_1 + i_1 = 28$; $I_2 + i_2 = 26$. This is once again very close to the mode of the Harnagian population described from Welshpool, and there can be no doubt of the identity of the two forms.

HORIZONS AND LOCALITIES. Bancroft (1949 : 294) recorded *Salterolithus caractaci* from two closely adjacent excavations, localized as being 700 feet due north of Glenburrell Farm, Horderley, from which abundant specimens were collected, and it was partly upon these discoveries that he founded the *Salterolithus caractaci* Zone of the Harnagian Stage. *S. caractaci* has also been found, at apparently the same horizon, about 90 yards south-east of the eastern end of the large disused quarry in Hoar Edge Grits by the south-western bank of the River Onny south-west of Round House, Horderley. Elsewhere in the Harnagian of the Caradoc Area, fragmentary evidence suggests that the species may occur in the stream-section just east of Gutter Cottage, east-north-east of Hope Bowdler.

Bancroft wrote (1949 : 294) " at the horizon of the *Horderleyella* burst at Horderley there is a form in which I_3 seems to extend farther anteriorly than in *Salterolithus caractaci* forma typica ". The horizon of the so-called " *Horderleyella* burst " is now believed to form part of the *Broeggerolithus broeggeri* Zone of the Soudleyan Stage. The species in question is probably that listed subsequently as *Salterolithus* sp. nov. (Dean, 1958 : 203), and figured here (Pl. 15, figs. 4, 9) as *S. caractaci* from the stream-section at the extreme north-eastern corner of Smeathen Wood, near Horderley. At the time the former identification was made it appeared that the species might be new, but additional specimens, together with the detailed descriptions of *S. caractaci* by Cave and Whittard, have shown that the Soudleyan form falls within the limits of variation of *S. caractaci* itself. The species occurring in the Soudleyan of Pontesford Brook, near Pontesbury (Dean, 1958 : 228), is apparently the same as that from Smeathen Wood.

In the Shelve Inlier *Salterolithus caractaci* is recorded from near the top of the Aldress Shales, from the Hagley Shales, and from the Whittery Shales, all of which horizons are included in the *Broeggerolithus broeggeri* Zone of the Soudleyan (Whittard, 1958 : 86–87). These strata are also equated with part of the *Diplograptus multidens* Zone (Whittard, 1956 : 5), thus affording some confirmation of the correlation of shelly and graptolitic faunas proposed for south Shropshire (Dean, 1958 : 227).

FIGURED SPECIMENS. BM. In. 51339 (Pl. 15, fig. 1) ; BM. In. 51340 (Pl. 15, fig. 2) ; both from the Harnagian Stage. BM. In. 51205 (Pl. 15, fig. 9) ; BM. In. 51207 (Pl. 15, fig. 4) ; BM. In. 51193 (Pl. 15, fig. 6) ; all from the Lower Soudleyan Stage.

Salterolithus praecursor sp. nov.

(Pl. 15, figs. 3, 5, 7, 8, 10–12)

1929*a*. *Salterolithus* sp., Bancroft, p. 81.

DESCRIPTION. The cephalon is normally moderately convex, both longitudinally and transversely, and sub-semicircular in plan, although anterolaterally it sometimes appears slightly angular when flattened. The length is about, or slightly more than, half the maximum breadth when uncrushed, and the largest-known specimen is 24 mm. wide, excluding genal spines. The glabella is tumid, slightly expanded anteriorly, about twice as long as broad, separated from the plump, quadrant-shaped cheek-lobes by broad, moderately-deep axial furrows which are slightly convex outwards. There is a poorly-defined occipital furrow and the occipital ring is produced to form a small spine directed backwards and upwards. The pleuroccipital segment is small, extending only halfway from the axial furrow towards the lateral margin, and is separated from the cheek-lobes by a pleuroccipital furrow which becomes shallower and broader (*exsag.*) outwards. The fringe has a flat upper surface and is only moderately declined anteriorly and laterally. It is relatively broad (*exsag.*), about one quarter to one third of the cephalic length, and of fairly uniform width almost as far as the posterolateral borders which are produced backwards to form small " ears " terminating laterally in stout genal spines, each of which is curved outwards and backwards and carries a longitudinal median ridge on the underside. There are five concentric rows of fringe-pits which are complete or nearly so, E_{1-3} and I_{1-2}, and of these E_1 and I_{1-2} comprise pits of approximately uniform size, slightly larger than those of adjacent rows. At the median line the rows I_{1-2} are flexed forwards slightly so as to accommodate the front of the glabella. There is a marked concentric arrangement of pits, with a slightly less marked radial arrangement. E_{1-3} are grouped closely together, but well-defined concentric bands occur between E_1–I_1, and between I_1–I_2 ; the first of these corresponds in position with a well-developed girder, bearing longitudinal striae, on the lower lamella of the fringe, and the second with a pseudogirder which is only developed laterally and posterolaterally. As one might expect, the number of fringe pits varies, particularly with the size of the individual trilobite, and the number present in rows E_{2-3} ranges from about 35 in a cephalon 7 mm. wide to 54 in one 24 mm. wide. For the principal rows of pits the number present is $E_1 + e_1 = 21–25$ (variation), 22 (mode) ; $E_{2-3} + e_{2-3} = 43–54$ (variation), 49 (mode) ; $I_1 + i_1 = 19–23$ (variation), 22 (mode) ; insufficient material has been found with I_2 intact, but in the holotype this row contains 21 pits. Auxiliary pits are commonest in the anterior and lateral portions of the fringe, where they are almost confined to E_{2-3}, those of E_3 being sometimes slightly displaced outwards.

The thorax and pygidium are not known from the type-locality, but an immature whole individual which probably belongs to the species is figured here from the Wallsbank district (Pl. 5, fig. 12). The thorax is of normal trinucleid type, with six segments and an axis occupying just less than one quarter of the total breadth. The pygidium, preserved as an internal mould, is subtriangular in outline, bluntly-pointed posteriorly, and the axis, which carries at least three small axial rings, is weakly defined, grading into the side-lobes where there are only two pleurae visible.

HORIZON AND LOCALITIES. The holotype, together with the paratypes In. 52031 and In. 52036, is from the south side of Coundmoor Brook, about 20 feet above stream level and 1340 yards south-west of Harnage Farm. The other paratype, In. 52017 is from the bed of Coundmoor Brook by the north bank, about 1320 yards south-west of Harnage Farm, In. 52041 from the south bank of Coundmoor Brook 1356 yards south-west of Harnage Farm, and the whole individual In. 54027 from the south bank of The Gutter, 450 yards east-south-east of Gutter Cottage, near Wallsbank. All these occurrences are in grey shales and mudstones, the Harnage Shales (*s.s.*), belonging to the *Reuscholithus reuschi* Zone of the Harnagian Stage.

In a recent paper (Dean, 1958 : 201) it was suggested that the base of the Harnagian Stage in the Cressage district should be defined by the appearance of *Reuscholithus* and/or *Salterolithus*. The *Salterolithus* in question was not *S. praecursor* sp. nov., but *Broeggerolithus harnagensis* (Bancroft), a species which was at that time referred to *Salterolithus*. *Salterolithus praecursor* has not yet been discovered with certainty outside the Cressage district, where it occurs only uncommonly.

HOLOTYPE. BM. In. 51479 (Pl. 15, fig. 3).

PARATYPES. BM. In. 50517 (Pl. 15, fig. 10) ; BM. In. 52031 (Pl. 15, fig. 5) ; BM. In. 52036 (Pl. 15, fig. 5).

OTHER FIGURED SPECIMENS. BM. In. 51840 (Pl. 15, fig. 7) ; BM. In. 52041 (Pl. 15, fig. 8) ; BM. In. 54027 (Pl. 15, fig. 12).

DISCUSSION. The only trinucleid trilobite which might usefully be compared with *Salterolithus praecursor* sp. nov. is *S. caractaci* (Murchison), discussed elsewhere in this paper, and confusion is unlikely as there are several differences between the two. Generally speaking *S. praecursor* is a much smaller species than *S. caractaci*, and the largest-known specimen is only 24 mm. wide across the base of the cephalon, compared with a width of 30 to 40 mm. which is not uncommon in the latter species. The cephalon of *S. praecursor* is also more rounded in outline and convex in form, though this is often obscured by its occurrence, with resultant crushing, in shaly mudstones. On the upper lamella of the fringe of *S. praecursor* the smooth concentric "bands" situated between E_{1-2} and between I_{1-2} are much narrower (*exsag.*) and less conspicuous than in *S. caractaci*, and the pit count for all the principal rows is noticeably less.

Genus ***SMEATHENIA*** nov.

DIAGNOSIS. Cephalon moderately convex both laterally and transversely, outline strongly and evenly curved, with the genal angles produced backwards to form large "ears". Cephalic fringe broad, maintaining its breadth evenly around the entire border. I_{1-2} continuous in front of the glabella. E_{1-3} extend to the genal angle, E_4 just fails to reach it, and E_5 is represented by adventitious pits in E_4 which may extend as far as R14. I_{1-2} and E_1 are composed of large pits, those of E_2 are slightly smaller, whilst those of E_{3-5} are noticeably smaller still. Thorax made up of six segments of typical trinucleid type, with narrow axis. Pygidium subtriangular in outline, usually with four or five axial rings, and two or three poorly-defined pleurae on the slightly inflated pleural lobes.

DISTRIBUTION. *Smeathenia* is known only from the southern portion of the Caradoc District of south Shropshire, where it is characteristic of the *Reuscholithus reuschi* Zone of the Harnagian Stage. It is broadly contemporaneous with *Broeggerolithus harnagensis* (Bancroft), but as yet the two have been found neither together nor in the same succession.

DISCUSSION. The new genus differs markedly from *Salterolithus*, to which the type-species has previously been referred, in possessing a well-developed E_4 together with a poorly-developed E_5.

TYPE-SPECIES. *Salterolithus smeathenensis* Bancroft, 1949.

Smeathenia smeathenensis (Bancroft)

(Pl. 13, figs. 7, 10–16)

1929*a*. *Salterolithus* cf. *intermedius* (Wade) Bancroft, p. 82.
1949. *Salterolithus smeathenensis* Bancroft, p. 292, pl. 9, figs. 1, 2, 2*a*.
1958. *"Salterolithus" smeathenensis* Bancroft: Whittard, p. 84.
1958. *Salterolithus smeathenensis* Bancroft: Dean, p. 201, pl. 26, fig. 4.

DESCRIPTION. Cephalon wider than long, with outline well rounded forming more than half an ellipse, the genal angles being produced backwards to form moderately large "ears". In the lectotype the length, including the "ears" and excluding the genal spines, is 12·5 mm. and the breadth 19 mm., but this specimen is slightly flattened. In occasional uncrushed specimens the maximum breadth is across the line of the pleuroccipital furrows, with the lateral margins converging backwards slightly towards the genal angles. The glabella is strongly convex longitudinally, slightly clavate in outline, usually with a poorly-defined median ocellus. Basal glabellar furrows are represented by one pair of small, deep, circular pits situated a short distance in front of the shallow occipital furrow which contains a pair of deep occipital pits slightly larger in size than those of the glabellar furrows.

The occipital ring is small, produced into a short occipital spine, directed backwards and upwards. The cheek-lobes are quadrant-shaped, moderately inflated, and smooth in the adult ; in the young form they carry coarse reticulation which becomes finer towards the inner margin of the fringe. Separating the cheek-lobes from the glabella are broad, shallow axial furrows with small, deep hypostomal pits sited well forward, close to the fringe. Near to the intersection of each axial furrow and the occipital ring there is a conspicuous pit situated to the rear of centre of each of the narrow (*exsag.*) pleuroccipital segments. The last-named are transversely straight as far as the fulcral sockets, beyond which the posterior margins of the fringe run outwards and backwards to the genal spines which are splayed outwards, each with a median groove. The border of the fringe is steeply declined, carrying, near the top, the marginal suture, separated from the pits of the upper lamella by a narrow marginal band. At the genal angle the line of the marginal suture skirts the pitted area and turns through more than a right angle so as to run parallel to, and then cut, the posterior margin of the fringe just before reaching its mid-point, finally disappearing below the underside of the cephalon. Possessing as it does a large number of concentric rows of pits, the fringe appears very broad (*exsag.*), particularly in flattened specimens, and maintains this breadth in front of the glabella. I_{1-2} and E_1 are continuous, both in front of the glabella and as far as the posterior margin of the fringe and genal angle ; they consist of pits which are larger than those of adjacent rows, and increase slightly in size towards the genal angles. I_1 and E_1 are separated on the upper lamella by a smooth, and occasionally slightly raised, concentric band which corresponds in position with the girder on the underside of the lower lamella. There is some diminution in the size of pits outwards from E_1. A strong radial arrangement is found only in I_{1-2} and E_1 where it extends to within two or three pits of the posterior fringe-margin, usually as far as R20 or R21. It has not proved practicable to use the usual notation for the rows of pits external to E_1. Although the frontal portion of the fringe lacks any satisfactory radial arrangement other than in I_{1-2} and E_1, from about R9 or R10 to R14 radial rows can be traced beyond E_1 where they curve outwards and backwards to the margin. In the lectotype E_2 has 27 pits and extends to the genal angle, E_3 has 30 pits and extends almost as far as E_2, E_4 and E_5 include numerous small pits several of which may be arranged in a random manner or so as to form a quincuncial pattern, E_5 extending as far as R14. It is frequently difficult, in the case of trinucleid genera such as *Salterolithus* and *Smeathenia*, to give adequate notational representation of the pits in the outermost concentric rows, and more recently Cave (1957) has found it convenient to work out the mode for both E_1 and the number of pits external to E_1 in *Salterolithus caractaci*. Such a procedure is particularly useful for *Smeathenia smeathenensis*, in which species the number of pits external to the girder may vary from 90 to 120, the number depending to some extent on the size of the individual. The fringe of the lectotype, a large cephalon 19 mm. wide, contains 95 pits external to E_1, but the corresponding number in a cephalon 14 mm. wide is only 73.

The thorax is made up of six segments of normal trinucleid type, and the greatest breadth is across the third, fourth and fifth segments, which are of equal size. The thoracic outline narrows forwards noticeably to the macropleural first thoracic segment. The side-lobes are flat and the axis moderately convex, occupying rather more than one-quarter of the total breadth. Each axial ring carries a deep articulating furrow in which is situated a pair of deep apodemal pits, and each pleura is divided into two pleural bands, of which the posterior band is the broader (*exsag.*), by a shallow pleural furrow which commences at the axial furrow and runs outwards and slightly backwards to the blunt, backwardly-directed, pleural point.

The pygidium is about three times as long as broad, its outline almost semi-elliptical or very slightly angular posteriorly and posterolaterally. The axis is between one-quarter and one-fifth of the total breadth, and is bounded by poorly-defined axial furrows ; there are four or five axial rings on the external mould, diminishing posteriorly, but the number on the internal mould is smaller, and of these the first two possess pairs of apodemal pits. The marginal parts of the pleural lobes are somewhat tumid both laterally and posteriorly, and there are usually two pairs of pleural furrows which deepen slightly towards the lateral margins. There is a gently convex postaxial ridge extending from the axis to the posterior margin, where a small blunt projection is usually developed.

HORIZON AND LOCALITIES. The type-locality is the section in the small cutting or cartway near the south-eastern corner of Smeathen Wood, 250 yards west-south-west of Wood House, five-sixths of a mile south of Horderley Station, where *S. smeathenensis* occurs in the lower part of the Smeathen Wood Beds associated with *Reuscholithus reuschi* Bancroft, *Phacopidina harnagensis* Bancroft and *Smeathenella harnagensis* Bancroft. The species is also abundant at the field exposure 550 yards north-west of Woolston House, Woolston, in a more arenaceous development of the Smeathen Wood Beds. All specimens known are from the *Reuscholithus reuschi* Zone of the Harnagian Stage in the general area of the River Onny Valley, and the species has not yet been found elsewhere.

LECTOTYPE, here selected. BM. In. 43321 (Pl. 13, fig. 16), the cephalon figured by Bancroft (1949, pl. 9, fig. 1).

PARATYPES. BM. In. 42082, an incomplete cephalon figured by Bancroft (1949, pl. 9, fig. 2) ; BM. In. 42092 (Pl. 13, fig. 15), the external mould of a pygidium figured by Bancroft (1949, pl. 9, fig. 2*a*) as a gutta-percha cast.

FIGURED SPECIMENS. BM. In. 49132 (Pl. 13, fig. 7) ; BM. In. 49560 (Pl. 13, figs. 10–12) ; BM. In. 50619 (Pl. 13, fig. 13) ; BM. In. 50767 (Pl. 13, fig. 14).

DISCUSSION. *Smeathenia smeathenensis*, the only species of the genus yet known, is easily distinguished from superficially similar trinucleids, for example *Salterolithus*, by the strong development of E_4 and the weak development of E_5.

Genus ***BROEGGEROLITHUS*** Lamont, 1935 *ex* Bancroft MS.

1933. *Broeggeria* Bancroft, p. 2. Preoccupied by *Broeggeria* Walcott, 1903.
1933. *Ulricholithus* Bancroft, p. 2. *Nomen nudum.*
1949. *Salterolithus* (*Ulricholithus*) Bancroft, p. 295.

The type-species of *Broeggerolithus* has been described by Bancroft (1929*a* : 85, pl. 1, figs. 6–8) and, more recently, by Whittard (1958 : 89, pl. 12, figs. 7–13). In diagnosing the genus the latter author has advocated (1958 : 88) that " forms with adventitious pits of an incipient E_3 series should be excluded from *Broeggerolithus* ". He has also expressed doubt as to whether *Broeggerolithus* and *Onnia* should be maintained as separate genera, but this view is not supported here (see p. 127). The genus *Broeggerolithus* covers a large and variable group of Trinucleidae, ranging through a considerable proportion of the Caradoc Series. Interpreted in a broad sense, it can be divided on the basis of fringe form into three groups of species as follows.

Group 1. Typified by *B. harnagensis* (Bancroft). Cephalic outline conspicuously rounded, almost semicircular, much shorter than broad. Coarse reticulation of the cheek-lobes may occur in the adult as well as the young forms. E_{1-2} and I_{1-2} are virtually complete, a few pits of E_2 being absent at the genal angle ; the pits of the four outermost rows are usually almost circular in form and of fairly uniform size. The upper lamella of the fringe is smooth, and there is no development of interradial or concentric ridges. E_2, and, to a much lesser degree, that part of the fringe between E_1 and E_2, contains several auxiliary pits, often irregularly disposed, though there is no suggestion of the development of an incipient E_3. The group is known only from the lowest Harnagian Stage in south Shropshire, and probably occurs at about the same horizon, or perhaps slightly earlier, in North Wales. Only one species has so far been described.

Group 2. Cephalon generally noticeably shorter than broad, with subangular outline. E_{1-2} and I_{1-2} usually complete, though up to a total of 8 pits may be absent from E_2 frontally, and up to 5 pits of E_1 are external at the genal angle owing to the incomplete development of E_2 there. Interradial ridges are generally strongly developed, particularly at E_1 which contains larger pits than, and is elevated above, adjacent concentric rows. Geological range is from the topmost Harnagian Stage to the Upper Longvillian Substage, and species, in stratigraphical order, include *ulrichi*, *broeggeri*, *constrictus*, *soudleyensis*, *globiceps* and, doubtfully, *simplex*. *B. ulrichi* differs in certain respects from the general plan outlined above, for example the cephalon is longer and more rounded, and there are several auxiliary pits in front of the glabella, a feature not usually found, but these differences are outweighed by the similarities. In any case, what is possibly the earliest member of the group might be expected to exhibit certain atypical or transitional characters.

Group 3. The third group of species of *Broeggerolithus* (*s.l.*) has not been distinguished by a separate subgeneric name, but this may eventually prove necessary when the various forms are better understood. So far only two species, *longiceps* and *transiens*, are definitely involved, ranging from the base of the Upper Longvillian Substage to the end of the Marshbrookian Stage in Shropshire. The cephalon has a well-rounded outline and is proportionately longer than in other groups, with a long, high glabella. The cheek-lobes of some specimens retain a reticulate surface even in the adult, but the importance of this is uncertain. There is only a weak development of interradial ridges on the upper lamella of the fringe which is almost flat, no one concentric row being elevated above the rest. E_{1-2} and I_{1-2} are complete or nearly so, even in the case of E_2 at the genal angle, and the size of pit does not vary markedly between the four outermost concentric rows. A few auxiliary pits may occur in E_2 laterally. The lessening development of interradial ridges parallels that in *B. ulrichi*, the earliest-known species of Group 2, and may indicate a retrogressive trend after the close of the Lower Longvillian Substage.

In his first paper dealing with the Trinucleidae Bancroft (1929*a* : table facing p. 76) gave a zonal table of the Caradoc succession and listed the "fringe-type of dominant group" at various horizons throughout the Series; certain details of these fringe-types were also enumerated in the same work (1929*a* : 73–76). The types of fringe listed by Bancroft are as follows: of them the lowest, *a*, does not concern us here as it is not an Anglo-Welsh form. There is a break in the Table between *g*. and *h*. corresponding with the Actonian Stage, which has not yet yielded identifiable trinucleid trilobites in Shropshire.

h. *superbus* type.
g. modified *gibbifrons* type (without depressed I_1).
f. *gibbifrons* type.
e. *soudleyensis* type (E_2 absent in front).
d. *broeggeri* type (intercalation in E_2 in front).
c. *caractaci* type (E_3 generally represented).
b. *favus* type.
a. *subradiatus* type.

Of these, *a*. is now *Reedolithus*, *b*. covers both *Marrolithus* and *Costonia*, *c*. is *Salterolithus*, *d*.–*g*. include various groups of *Broeggerolithus* (*s.l.*), and *h*. is now *Onnia*. The so-called "*gibbifrons*-type" of fringe is a misnomer and, although the name is widely quoted, is best abandoned. The type-specimens of *Trinucleus gibbifrons* McCoy, 1851 are lost. Williams (1948 : 80), in discussing the species, has shown that only rocks of Llandeilo age occur at the type-locality of Golden Grove, Llandilo, and it is suggested that the name be rejected. It seems more than likely that Bancroft's frequent usage of the term and its eponymous species stems from Reed's description and figure of a so-called *T. gibbifrons* McCoy (Reed, 1914 : 356, pl. 29, fig. 6) from Gelli Grin (probably the Gelli Grin Limestone or Calcareous Ash of Longvillian age) in the Bala District, a form which more closely resembles *Broeggerolithus globiceps* (Bancroft), and belongs apparently to *Broeggerolithus* (*s.s.*).

DISTRIBUTION. There is some ambiguity as to the stratigraphical level at which Bancroft believed *Broeggerolithus* made its appearance (Whittard, 1958 : 88), but the new collections available show that in south Shropshire *Broeggerolithus* (*s.l.*) appears in the lowest Harnagian and ranges upwards almost without interruption as far as the top of the Marshbrookian. The genus is not yet known with certainty from higher horizons in England or Wales. Geographically it is widespread, occurring also in the Shelve Inlier and at Pontesford, both in west Shropshire, as well as in many parts of North Wales, the Cross Fell Inlier, and the Dry Gill area of the Lake District. In Scandinavia it may possibly be represented by *Trinucleus discors* Angelin, 1854, a species usually placed in *Cryptolithus* but possessing two rows of pits external to the girder. Whittington (1941 : 30–34) refers the American species *Cryptolithus lorrainensis* Ruedemann, 1925, from the Lorraine Formation of New York State, to *C. bellulus* (Ulrich), but Lamont (1941 : 468, pl. 5, fig. 9) tentatively includes a small specimen from the Lorraine Formation of Rome, New York State, in the former species and states that both E_1 and E_2 are present on the fringe. Whether or not Lamont's specimen is the same as *C. lorrainensis* is outside the scope of this paper, but the presence of two rows of pits external to the girder strongly suggests that *Broeggerolithus* may be represented in the North American faunas.

TYPE-SPECIES. *Cryptolithus broeggeri* Bancroft, 1929, by original designation of Bancroft (*in* Lamont, 1935 : 320).

Broeggerolithus harnagensis (Bancroft)

(Pl. 16, figs. 5, 9, 13)

1929*a*. *Salterolithus harnagensis* Bancroft, p. 79, pl. 1, figs. 1, 2.
1933. *Salterolithus harnagensis* Bancroft : Bancroft, table 3.
1949. *Salterolithus harnagensis* Bancroft : Bancroft, p. 291.
1955. *Salterolithus harnagensis* Bancroft : Whittington *in* Whittington & Williams, p. 420.
1956. *Salterolithus harnagensis* Bancroft : Harper, p. 386.
1958. "*Salterolithus*" *harnagensis* Bancroft : Whittard, p. 83.
1958. *Salterolithus harnagensis* Bancroft : Dean, pp. 200, 201.

DESCRIPTION. The cephalic outline is well rounded, almost semicircular, the maximum breadth being a little more or less than two and a half times the median length, excluding occipital spine. The glabella is clavate, swollen anteriorly, with a small median ocellus and, apparently, does not stand very high above the plump cheek-lobes, from which it is separated by broad, shallow, almost straight, axial furrows containing large, deep, hypostomal pits. The surface of the cheek-lobes of young individuals is almost always coarsely reticulate, but occasionally may be smooth and it is not yet clear whether this is a primary feature or merely an accident of preservation. The front of the glabella intrudes only slightly on to the fringe and I_2, continuous there, is barely flexed forwards in consequence. No undoubted glabellar furrows have been seen, but there is a pair of deep apodemal pits situated just inwards from the axial furrows, immediately in front of the occipital furrow. The latter is broad (*sag.*), shallow, and ends laterally in a pair of deep occipital pits ; it delimits a small occipital ring which is directed upwards and slightly backwards, and produced into a small occipital spine. At the outer ends of the occipital ring are sited a pair of deep pits indenting the posterior margin ; from them the narrow (*exsag.*) pleuroccipital segment and moderately deep pleuroccipital furrow run straight outwards to the fulcral sockets, less than halfway to the lateral margins. From the fulcral sockets the posterior margins of the fringe, slightly convex rearwards, are directed outwards and fairly markedly backwards so as to form large " ears ". The genal spines are imperfectly known, but appear to be smooth on their upper surfaces, longitudinally ridged on the under surfaces, and strongly divergent rearwards. There is a narrow marginal band, truncated by the vertical border, just below the top of which runs the marginal suture, of normal trinucleid type.

The cephalic fringe is moderately broad, uniformly so over most of its length, expanding markedly behind the posterolateral angles of the cheek-lobes. The upper lamella is generally smooth, and no concentric or interradial ridges are developed. E_{1-2} and I_{1-2} are continuous in front of the glabella, and only one or perhaps two pits of E_2 are generally absent at the genal angle. The difference in size between the pits of the four outermost rows is not obvious, though those of E_1 and I_{1-2} become slightly larger posterolaterally. Radial arrangement of the fringe pits is not nearly so conspicuous as in later forms of *Broeggerolithus*, particularly outside E_1, and the radii may be straight or flexed slightly either backwards or forwards. Several auxiliary pits are present in E_2, and these are sometimes displaced slightly out of concentric line, either outwards or inwards. The number of pits present in each of the four outermost rows is as below ; no mode is given as this would be unjustified on the basis of the material available. $E_2 + e_2 = 27–28$, $E_1 + e_1 = 23–24$, $I_1 + i_1 = 23–24$, $I_2 + i_2 = 22–24$. The fringe notation for the lectotype is E_1 1–23, E_2 1–22 ; e_2 0, vi, x, xiii, xvi ; I_1 1–23, I_2 1–22 ; i_2 xx. I_3, and the area internal to it, is incompletely preserved but appears to extend from at least as far forwards as R12. There are nine pits along the posterior margin of the fringe.

On the underside of the fringe the girder, well developed centrally, becomes weaker near the genal angles where it is continuous with the longitudinal ridges on the genal spines, and two pseudo-girders, I_{1-2} and I_{2-3}, become stronger near the genal angles. All these concentric ridges carry longitudinal striae. In the median region of the lower lamella some of the pits of E_{1-2} and I_{1-2} are paired in shallow, radial sulci, and one pair of I_{1-2} pits has been found twinned ; the radial sulci quickly die out laterally.

In another specimen, which is only tentatively assigned to the species, BM. In. 52041 (Pl. 16, fig. 1), the pits of E_2 are noticeably smaller and more densely crowded, so that several are displaced out of line, though there is no suggestion of another concentric row. This specimen is so far unique, but may eventually prove to merit at least subspecific separation, though the general appearance is similar to that of *B. harnagensis* and, apart from E_2, all the concentric rows contain a comparable number of pits. The specimen is more noteworthy, however, for its retention of part of the test. The surface of the cheek-lobe shows vestigial coarse reticulation, but on microscopic examination the test proves also to be covered with minute, round punctae. A series of quite distinct punctae, larger and more irregular in both form and distribution, is situated between each of the hypostomal pits and the pitted area of the fringe, and may possibly denote the position of sensory hairs. An identical structure is noted later in the description of *Onnia superba*, and has not apparently been found previously in trinucleids.

The thorax is unknown.

The pygidium is triangular in outline, the maximum breadth being three times the length. The axis is about one-sixth of the total breadth, and triangular in plan, just attaining the tip of the pygidium. There are twelve or thirteen axial rings, the first two of which are completely and deeply delimited, the remainder becoming less distinct towards the tip. The pleural lobes are slightly swollen just outside the axial furrows and, again, near the margin, the position of which is marked by a small, raised rim. Apart from the articulating furrow only two pleural furrows are seen, continuous with their corresponding axial rings ; they become deeper laterally, but diminish in strength posteriorly. The border is, for the most part, steeply declined, except at and near the bluntly pointed tip of the pygidium, where its declination is much less.

HORIZON AND LOCALITIES. The species first appears in south Shropshire in the thin topmost layer of the Hoar Edge Grits; at this horizon, probably as a result of the shallow, sandy environment, it has not yet been found to be accompanied by *Reuscholithus* or any other trilobite, but the stratum is, nevertheless, taken as the basal bed of the Harnagian Stage at that point, following conformably upon the remainder of the Hoar Edge Grits, of Costonian age. For practical purposes the basal bed is included with the *Reuscholithus reuschi* Zone, as there is insufficient basis for erecting a *B. harnagensis* Zone. Immediately above the basal sandstone the species becomes more abundant in the grey shales and mudstones of the Harnage Shales proper, accompanied by *Reuscholithus reuschi.* It was from this horizon that the type-specimens were obtained, the type-locality being in the south bank of Coundmoor Brook, 1340 yards south-west of Harnage Farm. *B. harnagensis* has been found in numbers only in the Coundmoor Brook district of south Shropshire; farther south it is represented by a closely similar form described later as *B.* cf. *harnagensis.*

LECTOTYPE, here selected. BM. In. 42081 (Pl. 16, fig. 5), the cephalon figured by Bancroft (1929*a*, pl. 1, fig. 1).

PARATYPE. BM. In. 49024 (Pl. 16, fig. 13), the nearly complete pygidium figured by Bancroft (1929*a*, pl. 1, fig. 2).

FIGURED SPECIMENS. BM. In. 54029 (Pl. 16, fig. 9); doubtfully, BM. In. 52041 (Pl. 16, fig. 1).

DISCUSSION. The Shropshire species was recorded by Bancroft (1933: Table 3) from the Derfel Limestone of Bala, but material from that horizon has since been figured and described as *Salterolithus* cf. *harnagensis* by Whittington (*in* Whittington & Williams, 1955: 420, pl. 40, figs. 94–96, 100, 101) who has shown that several minor differences exist between the two forms. In particular we may note that the Bala specimens have fewer pits in I_1 and E_{1-2}, E_2 pits which are much smaller than those of adjacent rows, and that auxiliary pits of E_2 occur predominantly in the lateral parts of the fringe, whereas in the Shropshire species there may be several anteriorly. It seems likely that the two will prove eventually to be specifically distinct. The Derfel Limestone forms are believed to occur at or near the top of the Nant Hir Shales, belonging to the *Nemagraptus gracilis* Zone (Whittington & Williams, 1955: 397–398), and this horizon cannot be far removed from that of the earliest appearance of *B. harnagensis* in south Shropshire. There the basal Harnagian stratum forming the topmost Hoar Edge Grits is underlain by Costonian beds containing graptolites of the *N. gracilis* Zone and overlain by Harnage Shales belonging to the *Diplograptus multidens* Zone (Dean, 1958: 228), and it is not yet clear to which of the two graptolite zones it should be assigned.

***Broeggerolithus* cf. *harnagensis* (Bancroft)**

(Pl. 16, figs. 7, 11)

1949. *Salterolithus* aff. *harnagensis* Bancroft: Bancroft, p. 291, pl. 10, fig. 15.

The southernmost occurrences of forms resembling *B. harnagensis* yet known are all in Neptunian dykes filling fissures in Uriconian rocks at the disused quarry on the southern flank of Hazler Hill, east of Church Stretton. All the specimens known belong to a form which Bancroft figured as *Salterolithus* aff. *harnagensis*, a name which implies that he considered it to be distinct from, though related to, *Broeggerolithus harnagensis* itself. He cited as differences (1949 : 291) the presence of an extra pit in E_1, and others in E_2 frontally, at or near the median line. However, other specimens from Hazler Hill show that the above features are not constant in all individuals, and in view of the variation shown by *B. harnagensis* it is considered unlikely that we are dealing with a different species. The lack of adequate well-preserved material makes certain specific identification inadvisable, but a smaller cephalon 10 mm. wide, BM. In. 50502, has the following estimated pit-count for the outermost rows $E_2 + e_2 = 24$, $E_1 + e_1 = 23$, $I_1 + i_1 = 21$, $I_2 + i_2 = 21$. These figures compare closely with those one might reasonably expect from an immature individual of *B. harnagensis*, and are very near to those given by Whittington (*in* Whittington & Williams, 1955 : 420–421) for the Derfel Limestone specimens, though the size of these is not stated.

FIGURED SPECIMENS. BM. In. 42093 (Pl. 16, fig. 11) ; BM. In. 50500 (Pl. 16, fig. 7).

Broeggerolithus? sp.

(Pl. 16, fig. 2)

From the type-locality of *Broeggerolithus harnagensis* in Coundmoor Brook there has been collected a unique cephalon which presents some difficulties with regard to generic classification. The cephalon, though slightly damaged, is apparently subsemicircular in outline, the median length much less than half the breadth, with the genal angles set far back so as to form exceptionally large " ears ". The glabella is incomplete but expands anteriorly and has a pair of deep apodemal pits just in front of a pair of similarly-sized occipital pits situated immediately inside the outer ends of the occipital furrow. The occipital ring is small and short, and there appears to have been an occipital spine, now broken off. The moderately convex cheek-lobes are smooth, separated from the glabella by very broad axial furrows which shallow anteriorly and contain deep, round hypostomal pits well forwards. The pleuroccipital furrow is narrow (*exsag.*) and deep ; both it and the small pleuroccipital segment extend to the fulcral sockets, situated only about one-third of the distance from the axial furrows to the lateral margin.

The fringe is fairly broad (*sag.*) anteriorly where there are four continuous rows of pits, E_{1-2} and I_{1-2}, and remains of even breadth as far as about R20 when it expands suddenly and markedly, extending about halfway from the lateral margin to the axial furrows and producing the large " ears " noted above. As far as can be seen the pits of the outer four, and perhaps five, rows are of almost similar size, those of E_2 being only very slightly smaller. Broad concentric " bands " are found on the smooth upper lamella between E_1 and I_1, and between I_1 and I_2. The number of pits in the outermost concentric rows is $E_2 + e_2 = 27$, $E_1 + e_1 = 25$, $I_1 + i_1 = 27$, $I_2 + i_2 = 24$. These figures show a generally higher count than the corresponding data for *B. harnagensis* but the number of pits along the posterior margin of the fringe, nine, is the same. The cephalon is generally similar in many respects to that of *B. harnagensis*, but a very conspicuous difference is the presence of several pits, equal in size to those of E_2, situated between E_1 and E_2. These do not displace the concentric line of E_2 outwards in any way, and the pit walls separating them from the pits of E_1 and E_2 are very thin, so that we can hardly consider that they are causing the production of an incipient E_3, the undoubted presence of which would necessitate the inclusion of the specimen in *Salterolithus*. The extra pits number four in the left half of the fringe, but there appear to be more in the right half, and, even though the main concentration is near the anterolateral angle of each half, the two halves are not symmetrical. In consequence it has been thought advisable merely to assign the specimen tentatively to *Broeggerolithus* until more material is available, though the random, asymmetrical arrangement of the fringe pits suggests that it may be an abberrant form possibly related to *B. harnagensis*.

HORIZON AND LOCALITY. Harnagian Stage, Zone of *Reuscholithus reuschi*, south bank of Coundmoor Brook, 1356 yards south-west of Harnage Farm.

FIGURED SPECIMEN. BM. In. 54030 (Pl. 16, fig. 2).

Broeggerolithus ulrichi (Bancroft)

(Pl. 17, figs. 10, 11)

1933. *Ulricholithus ulrichi* Bancroft, p. 2, table 2, MS. name only.
1949. *Salterolithus* (*Ulricholithus*) *ulrichi* Bancroft, p. 296, pl. 9, fig. 14.
1958. *Salterolithus* (*Ulricholithus*) *ulrichi* Bancroft : Whittard, p. 84, pl. 12, fig. 1.
1958. *Ulricholithus ulrichi* (Bancroft) : Dean, pp. 200–202, pl. 26, fig. 6.

DESCRIPTION. Owing to the fact that the holotype is merely an incomplete half of a cephalon preserved as an external mould, the following description is founded on additional topotype material.

Cephalic outline well rounded, almost semicircular but becoming straight sided posterolaterally ; its length, excluding occipital and genal spines, is rather more than half the maximum breadth. The glabella is moderately convex, slightly clavate anteriorly, and no median ocellus has yet been seen. No glabellar furrows have been found preserved, but most of the material available is crushed or incomplete. The cheek-lobes are smooth, gently convex, longer than broad, and separated from the glabella by broad, moderately deep axial furrows in which small, hypostomal pits are sited well forwards. The occipital ring is small, delimited by a shallow occipital furrow ; apparently there is an occipital spine, but it has not yet been found intact. The pleuroccipital furrow is shallow and the pleuroccipital segment small and narrow (*exsag.*). Beyond the pleuroccipital segment the posterior margins of the fringe are straight and sweep back gently towards the genal spines ; the latter are prismatic in cross-section, tapering from stout bases to slender points. Each has a median groove on its upper surface and curves outwards and backwards at about 20 degrees to the median line. The cephalic fringe is flat, broad, and of fairly even breadth ; it is moderately declined laterally and apparently less so anteriorly. Four rows of pits, E_{1-2} and I_{1-2}, are continuous in front of the glabella, which encroaches a little on the fringe causing some flexing forwards of the concentric rows of pits there. E_1 and I_1 consist of pits slightly larger than those of neighbouring rows; the pits of I_2 are of similar size near the genal angle, but become smaller as they approach the median line. In general the pits of E_2 are somewhat smaller than those of E_1 and I_1, and they diminish slightly towards the genal angle. Interradial ridges are developed on a small scale but include only the rows E_{1-2} and I_1; in the case of E_1 they appear more conspicuous owing to the fact that the row is raised slightly above adjacent rows. The concentric lines of E_{1-2} and I_1 are set fairly close together, but I_2 is separated from I_1 by a relatively broad concentric band, corresponding in position with a poorly-developed pseudogirder on the underside of the fringe. The true girder, between E_1 and I_1, is strongly developed, but there is no corresponding feature on the upper lamella. The amount of well-preserved topotype material does not warrant the publication of figures showing the average number of pits present in the fringe, but a cephalon about 15 mm. wide has the following notation $E_1 = 1\text{–}22$; $E_2 = 1\text{–}19$; $e_2 = 0$, i, iii, iv; $I_1 = 1\text{–}22$; $I_2 = 1\text{–}21$; $I_3 = 13\text{–}21$; $i_3 =$ xvii, xviii; I_4 is represented only by a few pits in the angle formed by the cheek-lobe and the posterior margin of the fringe. The number of pits present does not appear to increase appreciably in larger individuals, and in one cephalon 24 mm. wide the number of pits in E_1 and I_1 is only 23 per row. Particularly characteristic is the presence of several auxiliary e_2 pits in front of the glabella; some of these may be somewhat irregular in their arrangement, but they can hardly be considered as adventitious pits, and Bancroft's assertion that a few pits of E_3 may be present is thought to be unjustified. The usual number of pits along the posterior margin of the fringe is 6 or 7, and the average number of E_1 pits external posterolaterally near the genal angle appears to be 3. There is a small raised marginal rim to the fringe, and just below and outside this runs the marginal suture, which extends to the genal angle, where it turns inwards through rather more than a right-angle and almost immediately cuts the posterior margin of the fringe.

The thorax is unknown.

The pygidium is three times as broad as long, almost semi-elliptical in outline but with a bluntly-pointed tip. The front of the axis occupies about one-fifth of the maximum breadth, tapering and extending to the rear margin which is marked by a small raised rim. The axis is only slightly convex, and bounded by poorly-developed axial furrows. The pleural lobes are almost flat near the axis but become slightly swollen towards the margin. In addition to the articulating furrow there is one pair of pleural furrows; these run straight outwards and slightly back from the axial furrows for about three-quarters of their length, and then, on encountering the swollen area of the pleural lobes, curve backwards to the margin. There are two pairs of faint rib furrows which become marked only at the margin which they meet close to, and just behind, the pleural furrows. The border of the pygidium is steeply declined, though slightly less so behind the termination of the axis.

HORIZON AND LOCALITIES. The type-locality is in the stream-section in Middle House Dingle, 120 yards west-north-west of Middle House, 3½ miles north of Welshpool, Montgomeryshire, where the species is found also in strata immediately underlying those of the type-locality. According to Bancroft the horizon is in the uppermost portion of the Harnagian Stage. *Broeggerolithus* [*Ulricholithus*] *ulrichi* was recorded by Bancroft (1949 : 296) from two localities in south Shropshire, both in the vicinity of Glenburrell Farm, Horderley. One locality is by the north-west side of the track 50 yards west-north-west of Glenburrell Farm, and the second is by the north-west side of the same track about 15 yards north-east of the first locality. The material from these beds is fragmentary and poorly preserved but appears to be at least close to *B. ulrichi*. The horizon of these specimens is the lowest part of the Glenburrell Beds, below the appearance of *Broeggerolithus broeggeri* at the base of the Soudleyan Stage, and their Harnagian age seems to be correct.

HOLOTYPE. BM. In. 42371.

FIGURED SPECIMENS. BM. In. 49708 (Pl. 17, fig. 10); BM. In. 54024 (Pl. 17, fig. 11).

DISCUSSION. It was stated by Bancroft (1949 : 295) that " *Ulricholithus* cannot be regarded as an early member of the genus *Broeggerolithus* which has reticulate ornamentation of the cephalon and in which stratigraphically early species are of notably smaller size than *Ulricholithus*. *Broeggerolithus* also has strongly elevated radial plates in E_1 and smaller modal numbers for the I_1 count ". After examination of topotype material the writer cannot agree with this argument, and Bancroft's inclusion of the species in *Salterolithus* must be rejected as there is no development of E_3. Apart from this, all the other characteristics, such as the development, even though on a small scale, of interradial ridges, the slight elevation of E_1 above adjacent rows, and the basic plan of four continuous rows of pits with a few pits of E_2 absent at the genal angles, indicate a close relationship to *Broeggerolithus* as typified by *B. broeggeri*, and *B. ulrichi* probably forms a link between that species and the earlier, more extreme development of *B. harnagensis*. None of the topotypes of *B. ulrichi* shows any trace of reticulation on the cephalon, but this is also true of most material belonging to the genus and cannot be considered of primary significance.

Broeggerolithus broeggeri (Bancroft)

(Pl. 16, figs. 3, 10)

1929*a*. *Cryptolithus broeggeri* Bancroft, p. 85, pl. 1, figs. 6–8.
1933. *Broeggeria broeggeri* (Bancroft) Bancroft, p. 2, tables 2, 3.
1935. *Broeggerolithus broeggeri* (Bancroft) Bancroft, p. 333.
1938*a*. *Cryptolithus broeggeri* Bancroft: Whittington, pp. 425, 428, 436, 450.
1940. *Broeggerolithus broeggeri* (Bancroft): Whittington, p. 245.
1941. *Broeggerolithus broeggeri* (Bancroft): Whittington, p. 24.
1949. *Broeggerolithus broeggeri* (Bancroft): Bancroft, p. 298, pl. 9, figs. 4, 5.
1958. *Broeggerolithus broeggeri* (Bancroft): Whittard, p. 89, pl. 12, figs. 7–13.
1958. *Broeggerolithus broeggeri* (Bancroft): Dean, p. 203, pl. 26, fig. 7.

This abundant and well-known species was described in detail by Bancroft (1929*a*) and the lectotype has more recently been redescribed in modern fashion by Whittard (1958 : 89), so little need be added here. The lectotype is representative of the population at the type-locality, both in size and number of pits. The underside of the fringe of the species shows a strongly-developed girder between E_1 and I_1 extending as far as the genal angles, where it curves outwards in line with the splayed genal spines. Between I_1 and I_2 there is a pseudogirder which is moderately well developed posterolaterally but which dies out near the median line ; the position of the pseudogirder corresponds with a narrow, slightly-raised concentric ridge on the upper lamella. Whittard (1958 : 90), in describing material from the Shelve Inlier belonging to the species, has noted that three pits of E_1 may be external posteriorly, whereas Bancroft (1929*a* : 85) claimed " one or two (rarely more) "; in practice, specimens from south Shropshire with three pits external are not uncommon and may be regarded as part of the normal population.

HORIZON AND LOCALITIES. The type-locality is in the eastern bank of the small stream-section by the extreme north-east corner of Smeathen Wood, near Horderley, about 150 yards almost due south of Round House. One of the paratypes now lost (Bancroft, 1929*a* : pl. 1, fig. 8) originated from the exposure behind the western end of Glenburrell Farm, Horderley, a locality at which the species was said to be abundant (Bancroft, 1929*a* : 86). The horizon of all these type-specimens is in the upper half of the Glenburrell Beds, the lower half of the Soudleyan Stage, to which the term *Broeggerolithus broeggeri* Zone is applied. The species can also be found at several other localities near Glenburrell Farm and in the bed of the River Onny nearby, all of them at the same horizon. It occurs also in the Glenburrell Beds exposed in the stream a quarter of a mile due west of Long Lane Quarry, north-west of Craven Arms.

LECTOTYPE, selected by Whittard (1958 : 88). BM. In. 42077 (Pl. 16, fig. 3), the cephalon figured by Bancroft (1929*a*, pl. 1, fig. 6).

PARATYPES. The other two specimens figured by Bancroft (1929*a*, pl. 1, figs. 7, 8), comprising a pygidium and incomplete cephalon, have not yet been traced, and are probably lost.

FIGURED SPECIMEN. BM. In. 50831 (Pl. 16, fig. 10).

***Broeggerolithus* cf. *broeggeri* (Bancroft)**

(Pl. 16, figs. 4, 8, 14)

In his original description of *Broeggerolithus broeggeri*, Bancroft (1929*a* : 86) emphasized that the specific name was not to be applied to specimens unless all or nearly all of them, even though resembling *B. broeggeri* in most respects, exhibited what he called " intercalated pits in front of the glabella ", now termed auxiliary pits. We are thus left with numerous individuals, some of them occurring in company with *B. broeggeri*, which show only relatively small, though constant, differences from that species. A whole individual typical of this group is figured here (Pl. 16, figs. 4, 8) from the type-locality of *B. broeggeri* itself. The cephalon is relatively longer than in *B. broeggeri* forma typica, the length of 9 mm. (excluding occipital spine) being half the breadth. This is noticeably more than is usual, but as there is some variation within the species this cannot be considered a reliable specific distinction. The notation for the fringe of the figured specimen is $E_1 = 1\text{–}22$; $E_2 = 1\text{–}19$; $I_1 = 1\text{–}22$; $I_2 = 1\text{–}20$; $I_3 = 11\text{–}21$; I_{4-5} are represented by a few pits in the angle formed by the cheek-lobe and the posterior margin of the fringe.

This is remarkably close to the notation given by Whittard (1958 : 90) for the lectotype of *B. broeggeri*, and the absence of any auxiliary pits from in front of the glabella is the only feature to distinguish the form from *B. broeggeri*; this is not considered sufficient to merit specific separation.

Trilobites generally similar to the above, though poorly-preserved, have been found in the *Glyptocrinus* Flags of the Chatwall district in the northern part of the Caradoc Area, and the cephalon of one is figured here (Pl. 16, fig. 14). It has been suggested (Dean, 1958 : 204) that they may possibly indicate the presence of the *B. broeggeri* Zone there. If this is so, then part at least of the *Glyptocrinus* Flags must be diachronic, as the same lithological horizon belongs to the *Broeggerolithus soudleyensis* Zone, Upper Soudleyan, farther south in the Onny Valley.

HORIZON AND LOCALITIES. In. 48937 is from the stream-section at the extreme north-eastern corner of Smeathen Wood, near Horderley, 150 yards south of Round House; the horizon is the *B. broeggeri* Zone of the Soudleyan. In. 51447 is from the *Glyptocrinus* Flags, ? *B. broeggeri* Zone, by the south side of the road 170 feet north-north-east of Chatwall Farm, Chatwall.

FIGURED SPECIMENS. BM. In. 48937 (Pl. 16, figs. 4, 8); BM. In. 51447 (Pl. 16, fig. 14).

Broeggerolithus constrictus Bancroft

(Pl. 16, figs. 6, 12)

1933. *Broeggeria constricta* Bancroft, table 3. MS. name only.
1949. *Broeggerolithus constrictus* Bancroft, p. 298, pl. 9, fig. 38.

Bancroft's account of the species was brief and included only the following diagnosis: "this group is characterized by having three pits of E_1 external towards the genal angle, by an abrupt constriction of the fringe behind the most posterior pit-radius with both E_1 and E_2, and by the unusual triangular contour of the pygidium" (1949 : 298). His description of the place of origin of *B. constrictus* referred to "the more important type-locality" near Ceunant, in the Welshpool District, but as he figured and described only one specimen, which thus became the holotype, one can only conclude that he had intended to base his species on a number of syntypes from differing localities. The holotype is an incomplete cephalon which does not show the fringe pits in front of the glabella. The rearmost portion of the fringe margin is obscure, and it is not quite clear whether the so-called constriction behind the rearmost pit of E_1 is actually present, or whether it is due to the breaking away of a small fragment of the test. Topotype specimens suggest that the latter may be the case, and show also that the constriction behind the rearmost pit of E_2 is not always so marked as in the holotype. In front of the glabella of the holotype it is estimated that three radial rows of pits are incomplete or absent, the remaining radial rows commencing in front of the axial furrows; thence towards the genal angle the number of primary radial rows (R) present in I_2, I_1, E_1 and E_2 respectively is 16, 16, 15 and 13, with only an occasional auxiliary pit in I_2 and E_1. I_3 is developed only from about R13 to the posterior margin. The marginal rim of the fringe is usually slightly raised, more so in topotype material than in the holotype, so that E_2 appears to be depressed, and there is a raised concentric ridge on the upper lamella between I_1 and I_2. Interradial ridges are strongly developed along most of E_1, especially anterolaterally. The surface of the cheek-lobes of the holotype shows slight traces of reticulation which is more evident on some of the topotype specimens. Near the intersection of the axial and pleuroccipital furrows the reticulation is fairly coarse, becoming finer towards the fringe both anteriorly and laterally; similarly there is a gradation from coarse to fine reticulation from the rear of the glabella towards the front.

The thorax is unknown.

Although Bancroft's diagnosis of *B. constrictus* referred to the " unusual triangular contour of the pygidium ", no pygidium was figured by him. No topotype pygidium has been found in his collection, so that a detailed description cannot be written.

HORIZON AND LOCALITIES. The type-locality is in the stream-section 515 yards west-south-west of Ceunant, four miles north-north-east of Welshpool, Montgomeryshire. The horizon was referred to by Bancroft (1949 : 299) as the *Broeggerolithus constrictus* Beds, at the base of the Soudleyan Stage, strata to which the name *Broeggeria broeggeri-constricta* Beds had been applied earlier (Bancroft, 1933 : Table 3). A locality in the Onny Valley was also claimed by Bancroft (1949 : 298) as having yielded *B. constrictus*, and from his information this can now be localized as being in the bed of the River Onny near the north bank, just east of the river-fence junction 55 yards almost due south of Round House, Horderley. The material from this locality has been examined by the writer and is considered to be probably referable to *Broeggerolithus broeggeri*, though the specimens are poorly preserved. The south Shropshire occurrence is in strata belonging to the Soudleyan Stage, Zone of *Broeggerolithus broeggeri*, and although these undoubtedly form part of the Lower Soudleyan it is not considered that the name *B. constrictus* Beds has any value. No records of the species are yet known outside the Onny Valley and the Welshpool District.

HOLOTYPE. BM. In. 42101 (Pl. 16, fig. 6).

FIGURED SPECIMEN. BM. In. 51883 (Pl. 16, fig. 12).

DISCUSSION. *Broeggerolithus constrictus* is of the same geological age as *B. broeggeri*, a species which it much resembles, and of which it may possibly prove to be merely a variety, though for the present the two are retained as separate species. The following features have been found useful in distinguishing them.

Usually *B. constrictus* has a slightly longer cephalon than *B. broeggeri*, though it may vary slightly; in this respect, some forms referred earlier to *B.* cf. *broeggeri* have a longer cephalon than the species itself. The glabella and cheek-lobes of topotype specimens of *B. constrictus* usually have a reticulate surface, even in mature individuals, contrasting with the smooth surface of these parts of the exoskeleton in *B. broeggeri*. Reticulation has not been found on the specimens referred by Bancroft to *B. constrictus* from the Onny Valley. The most noticeable difference between the two species is the smaller pit-count of *B. constrictus*, which has several fewer pits in the three outermost rows.

Broeggerolithus soudleyensis (Bancroft)

(Pl. 17, figs. 1–9, 17)

1929*a*. *Cryptolithus soudleyensis* Bancroft, p. 86, pl. 1, figs. 9–11.
1933. *Broeggeria soudleyensis* (Bancroft) Bancroft, table 2.
1935. *Broeggerolithus soudleyensis* (Bancroft) Bancroft, p. 334.
1938*a*. *Cryptolithus soudleyensis* Bancroft : Whittington, p. 451.
1940. *Broeggerolithus soudleyensis* (Bancroft) : Whittington, p. 245.
1941. *Broeggerolithus soudleyensis* (Bancroft) : Whittington, p. 27.
1945. *Broeggerolithus soudleyensis* (Bancroft) : Bancroft, pp. 210, 211, 239.
1958. *Broeggerolithus soudleyensis* (Bancroft) : Whittard, p. 91, pl. 12, fig. 14.
1958. *Broeggerolithus soudleyensis* (Bancroft) : Dean, p. 204, pl. 26, fig. 8.
1958. *Broeggerolithus* aff. *soudleyensis* (Bancroft) : Dean, pp. 207, 222.

DESCRIPTION. In the absence of suitable syntypes the following description is founded on topotype material.

Cephalon almost semielliptical in plan, slightly angular, the length being less than half the maximum breadth. The glabella is clavate anteriorly; bears a small median ocellus, and is strongly convex, standing high above the cheek-lobes from which it is separated by broad, moderately deep, gently curving axial furrows with deep, round, hypostomal pits situated well forwards A fairly deep occipital furrow marks off the small occipital ring which is produced backwards and upwards into an occipital spine ; the total length of the occipital ring and spine is about half that of the glabella. The fringe is narrow (*sag.*) in front of the glabella, widening slightly towards the genal angles. The pleuroccipital furrow is moderately deep, becoming shallower laterally ; it delimits a narrow pleuroccipital segment which is transversely straight as far as the fulcral sockets, beyond which the posterior margins of the fringe run backwards only slightly to the genal spines, the so-called "ears" being of very small size. Genal spines are rarely found intact ; they are divergent rearwards, and the longest yet seen is about the same length as the cephalon.

In front of the glabella, where several pits of E_2 are absent, the pits of all the concentric rows present are of similar size, but anterolaterally those of E_1 and I_1, particularly the latter, become larger. Over most of the fringe there is a conspicuous radial arrangement of pits and interradial ridges are developed, particularly in E_1 which is raised above the level of the adjacent concentric rows. There is a raised concentric ridge between I_1 and I_2 which corresponds in position with a pseudogirder, developed laterally, on the lower lamella of the fringe. The true girder, between E_1 and I_1, extends as far as the base of the genal spines, but is only strongly developed as far as the anterolateral angles. The notation for the fringe of a typical topotype cephalon (Pl. 17, figs. 9, 17) is $E_1 = 0–20$; $E_2 = 4–19$; $I_1 = 0–21$; $I_2 = 0–20$; $I_3 = 16–20$; $i_3 = \text{xvi}$; there is then a triangular area between the cheek-lobe and the posterior margin of the fringe which contains 9 pits. Particularly noticeable is the absence of auxiliary pits from nearly all parts of the fringe. There are seven pits along the posterior margin of the fringe.

The thorax and pygidium have not been found sufficiently well preserved for description.

A well-preserved cephalon about 11 mm. wide is figured here from the Upper Longvillian Substage (Pl. 17, figs. 2–4). The cephalic outline is slightly less angular anteriorly than the topotype just described and the pit-count is somewhat smaller, but as the cephalon is of a smaller individual this is not considered to be of specific importance. Three pits of E_2 are absent at the genal angle in the Upper Longvillian specimen but this number may vary from one to three in the species. The pit-notation is E_1 1–18, E_2 4–15, e_1 xv, e_2 xv; I_1 1–18; I_2 1–18; I_3 11–18, i_3 xi, xiii, xiv, xviii; internal to I_3 the triangular area between the fringe margin and the cheek-lobe is occupied by eight pits, and there are six pits situated along the posterior margin of the fringe.

Distribution. The species appears first as uncommon individuals accompanying *Broeggerolithus broeggeri* in the Lower Soudleyan of the Onny Valley. In the Upper Soudleyan *B. soudleyensis* becomes the dominant trilobite, sufficiently so as to be used as zonal index. It is widespread in the Caradoc area of Shropshire where it is found at many points, for example the Onny Valley south-east of Glenburrell Farm, Horderley, and the quarries a quarter-mile north-west of Sibdon Castle, near Craven Arms, and is also recorded from the Shelve Inlier and various parts of North Wales. Rare specimens have been found in the *Alternata* Limestone (Upper Longvillian) of Soudley Quarry, where they are accompanied by *Broeggerolithus longiceps* (Bancroft) and *Kjaerina bipartita* (Salter); this record is unusual for south Shropshire, but *B. soudleyensis* has been recorded from both the Lower and Upper Longvillian Substages of the Llansantffraid-ym-mechain district, Montgomeryshire (Whittington, 1938*a* : 451).

Type specimens. Of the three syntypes figured by Bancroft in his original description, only two have been recovered; both are poorly preserved and neither is figured here. They are now numbered BM. In. 49025 (probably Bancroft, 1929*a*, pl. 1, fig. 10) and BM. In. 42078 (Bancroft, 1929*a*, pl. 1, fig. 11). Both specimens are from the Soudley Sandstone, Upper Soudleyan Stage, of Soudley Quarry, just south-east of Soudley Pool, between Hope Bowdler and Ticklerton, about twenty feet below the base of the *Alternata* Limestone at that point. Neither specimen is considered to show any sufficiently diagnostic features of the species, so it is not proposed to select either as lectotype. The portion of an incomplete cephalon figured later by Bancroft (1949, pl. 9, fig. 6) from the Upper Soudleyan at the small quarry 100 yards south-east of Glenburrell Farm, Horderley, is also lost.

Figured specimens. BM. In. 49314 (Pl. 17, fig. 1); BM. In. 50584 (Pl. 17, figs. 2–4); BM. In. 51446 (Pl. 17, fig. 5); BM. In. 51445 (Pl. 17, fig. 6); BM. In. 50586 (Pl. 17, fig. 7); BM. In. 52856 (Pl. 17, fig. 8); BM. In. 54025 (Pl. 17, figs. 9, 17).

Discussion. *Broeggerolithus soudleyensis* bears a considerable resemblance to *B. broeggeri*, to which it is obviously related, but it is easily distinguished by the number of pits of E_2 absent from in front of the glabella. In his original description Bancroft (1929*a* : 86, 87) gave the number of pits absent as from four to eight, and in general it may be stated that the earliest known forms from the *Broeggerolithus broeggeri* Zone have a smaller number of pits absent anteriorly than later ones, but there is no uniform tendency to increase the number of pits lost, as the maximum number known to be absent in Upper Soudleyan specimens is eight, whilst in the Upper Longvillian it is six. From a later paper by Bancroft (1935 : 334) it appears probable that he did not regard the earliest forms from the *B. broeggeri* Zone as belonging to *B. soudleyensis*, but believed them to be what he called " rare mutations " of *B. broeggeri*. In the present paper the species is interpreted more widely so as to include all those forms in which from one to eight pits of E_2 are absent frontally. A more extreme example of the variation to be expected is shown by a fringe (Pl. 17, fig. 8) in which another break, from R5 to R6, occurs in E_2, in addition to that immediately in front of the glabella.

Broeggerolithus globiceps (Bancroft)

(Pl. 17, figs. 13, 15, 16)

1929*a*. *Cryptolithus globiceps* Bancroft, p. 88, pl. 2, figs. 1, 2.
1938. *Cryptolithus globiceps* Bancroft : Whittington, p. 53, pl. 6, fig. 1.
1938*a*. *Cryptolithus globiceps* Bancroft : Whittington, p. 450.
1940. *Broeggerolithus globiceps* (Bancroft) Whittington, p. 245.
1947. *Broeggerolithus globiceps* (Bancroft) : Harper, pp. 155, 172.
1958. *Broeggerolithus globiceps* (Bancroft) : Dean, p. 206, pl. 26, fig. 9.

DESCRIPTION. Cephalic outline is slightly subangular anterolaterally, but is generally fairly well rounded except for a small portion of the fringe in front of the glabella where the margin is transversely straight owing to the absence there of a few, normally 3, pits of E_2. The total length, excluding the occipital ring, is more than half the maximum breadth. The glabella is usually large, strongly convex, and stands high above the moderately swollen cheek-lobes. The anterior portion of the glabella encroaches on to the fringe, being accommodated by the flexing forwards of the concentric rows of pits ; the posterior portion, excluding the occipital ring, extends well to the rear of the pleuroccipital segment. Glabellar furrows are represented only by a pair of basal apodemal pits, just behind which is situated a pair of smaller, slit-like occipital pits. The shallow occipital furrow and small occipital ring are directed backwards and upwards at about 45 degrees to the horizontal, and there is a small occipital spine in the same plane. The axial furrows are gently convex outwards, broad and only moderately deep, with small, round, deep hypostomal pits at their outer ends. The broad, shallow pleuroccipital furrows and narrow (*exsag.*) pleuroccipital segments extend about half-way from the axial furrows towards the lateral margin. Beyond the fulcral sockets the posterior margins of the fringe are straight, directed backwards slightly towards the bases of the genal spines and forming very small " ears ". The genal spines themselves are prismatic, flat on top, slightly curved, and strongly splayed rearwards. The marginal suture is of the normal trinucleid type.

The fringe is generally flat, declined gently in front of the glabella and much more strongly at and near the genal angles. In front of and adjacent to the glabella the concentric rows E_{1-2} and I_{1-2} contain pits of equal size, but laterally those of E_1 soon become larger and maintain a uniformly large size from about R7 or R8 to the genal angle. The pits of I_1 begin to become noticeably larger and polygonal from about R15 onwards, and by the time they reach the genal angle may be slightly larger even than those of E_1. Interradial ridges are developed in the three outermost rows, being more conspicuous in E_1 which is slightly raised above the remainder of the upper lamella. The concentric ridge between I_1 and I_2 is not conspicuous. Insufficient well-preserved material has been found to justify the publication of average pit counts for the various rows, but the notation for the lectotype is E_1 0–21, E_2 2–20 ; e_1 xx, xxii ; I_1 0–22, I_2 0–21, I_3 13–22 ; i_1 xix, i_2 xxi, i_3 xxi. I_4 consists of about 7 pits from R18, and I_5 is represented by 2 or 3 small pits. The number of pits of E_2 absent from in front of the glabella is usually three, and the point where E_2 commences is marked by a small break in the line of the cephalic margin. At and near the genal angles four or five pits of E_2 and e_2 are more commonly absent, but this number may be as small as three. The number of pits along the posterior margin of the fringe is usually seven or eight. A well-preserved underside of the fringe has not yet been found, but external moulds show that between E_1 and I_1 there is a strong girder which is particularly well developed anteriorly. A moderately strong pseudogirder occurs between I_1 and I_2, whilst there is a suggestion of another pseudogirder posterolaterally between I_2 and I_3.

The thorax is not yet known, and no sufficiently well-preserved pygidium is available for description.

Horizons and localities. The type-locality is situated just east of the south-western corner of Rookery Wood, three-quarters of a mile south-east of Horderley ; the horizon is in the Lower Longvillian Substage, associated with *Dalmanella lepta* (Bancroft). Recently it has been found more convenient to group together as one horizon within the Lower Longvillian Bancroft's two discrete Zones of *Wattsella indica* and *W. lepta*, both in south Shropshire and at Welshpool (Dean, 1958 : 206 ; Cave & Dean, 1959 : 297). *Broeggerolithus globiceps* is taken as index-fossil for the Lower Longvillian of south Shropshire (Dean, 1958 : 206) and other localities where it is to be found include the large quarry by the roadside 280 yards south-east of Glenburrell Farm, Horderley ; the quarry by the west side of New House, 625 yards south-east of Glenburrell Farm ; the disused railway cutting by the south-west bank of the River Onny between points opposite Glenburrell Farm and New House ; Long Lane Quarry, two-thirds of a mile south-west of Cheney Longville ; the old quarries in the eastern part of Longville Plantation, respectively 720 yards north-west and 740 yards west-north-west of the Earthwork at Cheney Longville ; and the quarry by the east side of the road 590 yards east-north-east of Cwm Head Farm, one and a half miles north-east of Horderley.

The species has not yet been found in any of the other outcrops of the Caradoc Series in England, but it has been recorded from various parts of North Wales including the Llanfyllin District of the Berwyn Hills, and the Pwllheli District.

Lectotype, here selected. BM. In. 42076 (Pl. 17, fig. 15), an incomplete cephalon, preserved as an internal mould, figured by Bancroft (1929*a*, pl. 2, fig. 1) and, more recently, by Dean (1958, pl. 26, fig. 9).

Paratype. BM. In. 42075, an incomplete cephalon figured by Bancroft (1929*a*, pl. 2, fig. 2). The glabella of this specimen is slightly distorted and foreshortened, so that the projection of the posterior portion of the glabella behind the pleur-occipital segment is not apparent.

FIGURED SPECIMENS. BM. In. 49315 (Pl. 17, fig. 13); BM. In. 49321 (Pl. 17, fig. 16).

DISCUSSION. *Broeggerolithus globiceps* possesses certain features, such as well-developed interradial ridges, a raised E_1 row, and a general lack of auxiliary pits, which link it with *Broeggerolithus broeggeri*, but it is easily distinguished by the longer, more rounded cephalon, the conspicuous, tumid glabella, and by the absence of some pits of E_2 in front of the glabella. This last feature is reminiscent of *Broeggerolithus soudleyensis*, but the latter species has a much smaller number of fringe-pits as well as a shorter, more angular cephalon and a smaller glabella.

Broeggerolithus sp. (? nov.)

(Pl. 17, fig. 12)

Associated with *Broeggerolithus globiceps* (Bancroft) at its type-locality is another trinucleid, referred to *Broeggerolithus* (*s.s.*) which is represented only by a well-preserved half-fringe and incomplete glabella. In front of the glabella four concentric rows of pits are continuous, and contain pits of equal size. Laterally and postero-laterally the pits tend to increase in size, particularly those of E_1 and I_1 which are larger than those of the other rows, and which are of about equal size at the genal angle. E_1 is slightly elevated and interradial ridges are developed between the radial rows of the three outermost rows; the apex of each interradial ridge is situated between E_1 and E_2. The radial arrangement of pits is pronounced, but those of R6 are unevenly distributed; this is believed to be due to a slight malformation or injury, and corresponds with a small unevenness in the otherwise smooth margin of the fringe. The fringe-notation is $E_1 = 1–19$, $E_2 = 1–18$; $I_1 = 1–20$, $I_2 = 2–19$, $I_3 = 10–16, 18, 19$; $i_3 = \text{xv, xvi}$. I_4 is represented by 5 pits, irregularly arranged, from R16 outwards, and the remaining pits comprise a triangular cluster of five in the angle between the posterior margin of the fringe and the cheek-lobe. Only one pit of E_1 is external at the genal angle, and there are eight pits along the posterior margin of the fringe, which is straight and directed only slightly backwards to the genal angle.

HORIZON AND LOCALITY. The exposure in Rookery Wood, three-quarters of a mile south-east of Horderley, just east of the south-western corner. The horizon is in the middle subdivision of the Lower Longvillian Substage, characterized by *Dalmanella lepta* and *D. indica*.

FIGURED SPECIMEN. BM. In. 49313.

DISCUSSION. This form of *Broeggerolithus*, which may be new, differs from the associated *B. globiceps* in having a complete development of E_2 in front of the glabella, fewer pits of E_1 external at the genal angle, and a generally smaller pit count. The inadequate material makes comparison of the glabella in the two forms impossible, and it is not clear what relationship exists between them. Bancroft (1929*a* : 89) stated that *B. globiceps* occurred with a more abundant form, the fringe of which had a continuous E_2 row and was otherwise indistinguishable from that of *B. globiceps*. He regarded the two as members of the same dimorphic species, but if the form referred to by him is in fact the same as that figured here, it is considered that the differences are probably sufficient to justify specific separation when more material is available.

Broeggerolithus simplex sp. nov.

(Pl. 17, fig. 14)

DERIVATION OF NAME. *simplex* (Lat.) = simple, from the relatively uncomplicated arrangement of the fringe-pits.

DESCRIPTION. Outline of cephalon is bluntly pointed in front, and subangular anterolaterally. The median length, excluding occipital spine, is half the maximum breadth of 12 mm. The glabella is not preserved in the only specimen available, but the left cheek-lobe is intact, showing it to be only moderately convex. The fringe is flat and of even breadth as far as the anterolateral angles where it expands towards the posterior margin. In the frontal part of the fringe, as far as the anterolateral angles, the pits of the four continuous, concentric rows are of equal size, but towards the genal angles at least those of I_{1-2} become conspicuously larger. A slightly raised concentric ridge is developed posterolaterally on the upper lamella between I_1 and I_2. Small interradial ridges are situated between the radial rows of pits in E_{1-2} and I_1, which thus appear to lie in shallow radial suci, but concentric row E_1 is not raised above its neighbours and the height of only a few interradial ridges increases very slightly at the line of E_1. The posterior margins of the fringe are directed outwards and backwards sharply to the genal angles, forming moderately large " ears "; the genal spines are not preserved in the holotype.

The state of preservation of parts of the fringe makes it difficult to decipher the entire notation, but as far as can be determined it is as below. The large number of radial rows of pits is particularly conspicuous, though not very different from *B. broeggeri*. E_1 = 1–22, E_2 = 1–21 ; I_1 = 1–22, I_2 = 1–19, 21, 22, I_3 = 12–20 ; i_3 = xvii. Extension of the notation to the rows internal to I_3 has not proved practicable. Only one pit of E_1 is external at the genal angle, and the number of pits arranged along the posterior margin of the fringe is about eight.

The undersurface of the fringe, the thorax and the pygidium are not yet known.

HORIZON AND LOCALITY. The type-locality is the same as that for *Broeggerolithus globiceps* (Bancroft), namely, just east of the south-western corner of Rookery Wood, three-quarters of a mile south-east of Horderley. The horizon is the Zone of *Dalmanella indica* and *D. lepta*, in the Lower Longvillian Substage. Fragmentary evidence of what may prove eventually to be the same species has been found in the *Dalmanella horderleyensis* Zone of the Lower Longvillian Substage in the Onny Valley between Glenburrell Farm and New House, and at Long Lane Quarry, two-thirds of a mile south-west of Cheney Longville.

HOLOTYPE. BM. In. 50614. This is the only specimen as yet definitely assigned to the species.

Discussion. *Broeggerolithus simplex* is a distinctive small form and is unlikely to be confused with any of the contemporaneous Lower Longvillian trinucleids. It is only with hesitation that the species is included in Group 2 of *Broeggerolithus*, as it possesses certain features which are more reminiscent of species in Group 3. These are : a fairly flat fringe in which E_1 is not raised above other rows, and the posterior prolongation of the genal angles to form moderately large " ears ". Some of the interradial ridges are, however, slightly higher at the line of E_1, as in *Broeggerolithus* (*s.s.*), and the species is probably best regarded as intermediate between the two groups, or an early member of Group 3.

Whittington (1938 : 52, 53) has referred to trilobites which he called *Cryptolithus* cf. *gibbifrons* (McCoy) from the Lluest Quarry, Llanfyllin, Montgomeryshire, where they are accompanied by *Broeggerolithus globiceps* and other Lower Longvillian fossils including *Dalmanella horderleyensis* (Whittington). These forms were said to have four concentric rows of pits with conspicuous concentric arrangement in front of the glabella, and only one or two pits of E_1 external at the genal angle. The name used by Whittington was based on Bancroft's usage of *C. gibbifrons*, a term discussed earlier in this paper (page 104), and it seems more likely that the species in question might be either *Broeggerolithus* sp. (? nov.) or *B. simplex* sp. nov.

Broeggerolithus longiceps (Bancroft)

(Pl. 18, figs. 1, 4–6, 10)

1929*a*. *Cryptolithus longiceps* Bancroft, p. 89, pl. 2, figs. 3, 4.
1940. *Broeggerolithus longiceps* (Bancroft) Whittington, p. 245.
1945. *Broeggerolithus longiceps* (Bancroft) : Bancroft, p. 249.
1958. *Broeggerolithus longiceps* (Bancroft) : Dean, p. 207, pl. 26, fig. 10.

Description. Owing to the incompleteness of the type-material the following is based on both lectotype and topotype specimens.

The cephalon is usually almost semicircular in plan, though occasionally it may be slightly subangular anterolaterally and in front of the glabella ; the median length, excluding the occipital spine, is half the maximum breadth. The glabella is long and high, swollen anteriorly, where it encroaches on, and slightly overhangs, the fringe, and becomes narrow at the occipital furrow. This last is shallow and both it and the small occipital ring, which is produced into a small occipital spine, are in a plane directed backwards and steeply upwards. The internal mould shows a pair of small, basal apodemal pits situated just in front of the occipital furrow, in the rear half of which is a pair of slit-like occipital pits. There is a small ocellus at the apex of the glabella about its mid-point. The axial furrows are broad, gently convex outwards and only moderately deep, a feature usually exaggerated by crushing. The cheek-lobes are plump and, together with the glabella, often carry coarse reticulation, particularly when preserved in limestone. The pleuroccipital furrow is broad (*exsag.*) and shallow, bordering a narrow (*exsag.*) pleuroccipital segment ; the two run outwards, curving forwards very slightly, as far as the fulcral sockets, from which points the posterior margins of the fringe run outwards and sharply backwards to the bases of the backwardly-splayed genal spines, forming "ears" of fairly large size.

The fringe is flat and moderately broad (*exsag.*), becoming narrower anteriorly and broader towards the genal angles. From the limited uncrushed material available it is apparently only gently declined, both anteriorly and laterally. The four outer rows of pits are continuous in front of the glabella, where they consist of pits of equal size. Posterolaterally the pits of E_1 and I_{1-2} become larger, particularly those of I_1 which are conspicuously large near the genal angle. The upper lamella is generally smooth, interradial ridges being developed only on a small scale, so that from I_1 outwards the radial rows appear to be set in shallow sulci. No concentric row is raised above the others as happens in earlier species of *Broeggerolithus*, nor is I_1 depressed as claimed by Bancroft, though this may have appeared to be the case owing to the fact that a concentric ridge is noticeably developed between I_1 and I_2. A marginal rim of similar height is present, and there is another concentric ridge, less well developed, between E_1 and I_1; on the underside of the fringe the latter corresponds in position with a girder which is particularly well marked anteriorly and continued as a ridge on the underside of the genal spine. A smaller pseudogirder is present posterolaterally between I_1 and I_2. The usage of the normal fringe-notation presents some difficulties in the posterolateral parts of the fringe where, at first sight, there appear to be some auxiliary pits in E_2. There the pits form two sets of radiating lines in the outer part of the fringe, intersecting at an angle of about 60 to 70 degrees, and it may be difficult to decide which of the two should be interpreted as being continuous with the anterior radii. For the purpose of the following notation the radial rows in E_{1-2} and I_1 regarded as true radii are those which become progressively less divergent as they approach the genal angle. The pattern of fringe-pits in early Ordovician trinucleids is usually relatively simple, but in the earlier species of *Broeggerolithus* the problem outlined above is found on a small though increasing scale. In *B. longiceps* one is forced to regard as true radii those radial rows which are straight as far as the I_{1-2} pseudogirder, but which then flex forwards sharply. Using this method of interpretation the radii are seen to extend nearly to the genal angle, the apparent almost quincuncial arrangement being only superficial and auxiliary pits uncommon. The fringe notation for specimen BM. In. 52058, a typical mature topotype cephalon 24 mm. wide, is E_1 0–22, E_2 0–19; e_2 xviii, xix; I_1 0–23, I_2 0–22; i_2 ix, x. I_3 is represented by about 11 pits from R12 outwards, and there are about seven small pits in the I_4 region.

The number of adequately-preserved cephala is not large, but as far as can be judged the average number of pits in the principal rows of an adult specimen is $E_1 + e_1 = 24$, $E_2 + e_2 = 22$, $I_1 + i_1 = 23$, $I_2 + i_2 = 22$, $I_3 + i_3 = 12$ or 13. What is probably a small holaspid cephalon, 13 mm. wide, has the following pit-count in the four outer rows: $E_1 + e_1 = 21$, $E_2 + e_2 = 20$, $I_1 + i_1 = 21$, $I_2 + i_2 = 22$.

The thorax is unknown.

No pygidium was described by Bancroft, and none which can be definitely ascribed to the species is yet available. A few indifferently preserved pygidia of typical *Broeggerolithus* aspect have been found in the *Alternata* Limestone of the

Soudley district, but as more than one species of the genus is present there, it would be dangerous to assume they belong to *B. longiceps*.

HORIZONS AND LOCALITIES. The lectotype was collected from the exposure in the small stream by the west side of the road from Horderley to Marchbrook, about 480 yards north-north-east of Whittingslow. The locality is in the *Alternata* Limestone, the lower part of the Upper Longvillian Substage, and the species is found at this horizon at various localities throughout the Caradoc District, for example, the upper part of the old quarry by the east side of Soudley Pool, between Hope Bowdler and Ticklerton; in the cutting 200 feet south-east of Chatwall Hall; in the south side of the disused railway-cutting by the south bank of the River Onny, 175 yards south-south-east of New House, Horderley; and in the sides of Longville Lane, 445 yards north-west of the " Earthwork " at Cheney Longville. *Broeggerolithus longiceps* is also found, though less commonly, in the upper part of the Upper Longvillian Substage, comprising strata with *Kjaerina typa* Bancroft and *K. geniculata* Bancroft. At this horizon it is found, for example, in the north-east bank of the stream 280 yards south-east of New House, west of Marshbrook.

LECTOTYPE, here selected. BM. In. 42073 (Pl. 18, fig. 6), an almost complete cephalon preserved as an internal mould and figured by Bancroft (1929*a*, pl. 2, fig. 3).

PARATYPE. The other specimen figured by Bancroft (1929*a*, pl. 2, fig. 4), and comprising the external mould of a glabella and occipital ring, has not yet been traced.

FIGURED SPECIMENS. BM. In. 50591 (Pl. 18, fig. 5); BM. In. 50661 (Pl. 18, figs. 1, 10); BM. In. 50739 (Pl. 18, fig. 4).

DISCUSSION. *Broeggerolithus longiceps* differs considerably in detail from most Lower Longvillian species of the genus, but has some features in common with *B. simplex* sp. nov. However, the Upper Longvillian form is easily distinguished by its more rounded cephalon with large " ears ", together with fewer pits in E_2 and more in I_1. *B. longiceps* is also an apparently larger form than any of those in the Lower Longvillian, but it is not clear whether this is due to its occurrence in a more amenable environment or not.

Broeggerolithus transiens (Bancroft)

(Pl. 18, figs. 2, 3, 7, 8, 11–14)

1929*a*. *Cryptolithus transiens* Bancroft, p. 90, pl. 2, fig. 5.
1933. *Broeggeria transiens* (Bancroft) Bancroft, table 1.
1945. *Broeggerolithus transiens* (Bancroft) Bancroft, pp. 196, 197.
1948. *Broeggerolithus transiens* (Bancroft): Bancroft *in* Lamont, pp. 2, 5.
1949. *Broeggerolithus transiens* (Bancroft): Bancroft, p. 298, pl. 9, fig. 8.
1958. *Broeggerolithus transiens* (Bancroft): Dean, p. 208, pl. 26, fig. 11.

DESCRIPTION. Outline of the cephalon is usually well rounded, almost semicircular, though occasionally it may be slightly subangular anteriorly or anterolaterally. In front of the glabella the outline may appear slightly flattened owing to the narrowing of the fringe. The glabella is strongly convex, swollen anteriorly, and stands high above the tumid cheek-lobes from which it is separated by broad, fairly deep axial furrows containing small hypostomal pits situated well forwards. At the base of the glabella is a pair of small pits, and just behind these is another pair in the posterior half of the broad (*sag.*), shallow occipital furrow. The occipital ring is small, short and directed backwards and upwards, as is the small occipital spine into which it is produced. The pleuroccipital furrow is shallow, delimiting the narrow (*exsag.*) pleuroccipital segment which is transversely straight as far as the fulcral sockets, beyond which the posterior margin of the fringe runs outwards and rearwards to the genal angles, forming " ears " of moderate size. The junction of the occipital ring and the two halves of the pleuroccipital segment is marked by the presence of a pair of small apodemes. The genal spines extend rearwards more than the length of the cephalon, and are gently convex outwards ; they have a grooved upper surface, and a ridged lower surface.

The fringe is of even breadth, becoming slightly narrower in front of the glabella where four rows of pits are continuous. The surface of the upper lamella is generally flat, but small interradial ridges are developed anteriorly in the three outermost rows of pits. There is a slightly-raised concentric ridge between I_1 and I_2, and I_2 itself is depressed a little, especially anterolaterally. In front of the glabella all the pits are of equal size, but then, near the anterolateral angles, those of E_1 and I_{1-2} become much larger, though still of equal size, towards the genal angles. The marginal suture is of normal trinucleid type, but as it runs close to the pits of E_2 the marginal rim is extremely narrow. The mode and variation of the pits present are $E_1 + e_1 = 19$ (18–22) ; $E_2 + e_2 = 22$ (20–23) ; $I_1 + i_1 = 19$ (18–21) ; $I_2 + i_2 = 19$ (19–21) ; $I_3 + i_3 = 10$ (8–12) ; $I_4 + i_4 = 5$ (5–6). Pits along posterior margin of fringe = 7 (7–9). Pits external at genal angle = 1 (1–2).

As in *Broeggerolithus longiceps* the radii to the rear, and even just in front, of the anterolateral angles are flexed forwards at the I_{1-2} pseudogirder, and some auxiliary pits are present in E_2 in this portion of the fringe. The fringe of the holotype is incompletely preserved, but the notation in a topotype cephalon of comparable size, about 19 mm. wide, is $E_1 = 0–18$, $E_2 = 0–18$; $e_2 =$ xi, xii ; $I_1 = 0–17$, $I_2 = 0–17$, $I_3 = 12–17$; $i_3 =$ xii, xiv, xvii. Internal to I_3 there is a triangular group of seven pits between the cheek-lobe and the posterior margin of the fringe.

The underside of the fringe shows an E_1–I_1 girder which is particularly strongly developed anteriorly, and a much smaller I_{1-2} pseudogirder which only appears posterolaterally. The line of the girder is continued as the longitudinal median ridge on the underside of the genal spine. A particularly conspicuous feature of the pitting is the manner in which the pits of E_{1-2} are situated in straight, shallow, radial sulci which diminish in depth away from the median line. In the most centrally positioned sulci the pits of E_{1-2} are close together, almost twinned, but beyond about R3 they are distinctly separate.

The thorax contains six segments of typical trinucleid form ; the third, fourth and fifth segments are equidimensional and the thoracic outline narrows forwards and rearwards from these. The narrowest part of the thorax is across the first, macropleural segment, the anterolateral edges of which run sharply backwards and outwards from the fulcral processes. Each pleura is divided into two bands of about equal size by a pleural furrow which runs outwards and slightly backwards from the axial furrow to the backwardly-directed pleural point. The axis is narrow, about one-quarter of the total breadth, and delimited by straight, shallow axial furrows. Each axial segment is curved forwards centrally and also laterally to form a pair of nodes just inwards from the axial furrows. On the inner side of each node a deep apodemal pit is situated in the deep, broad (*sag.*) articulating furrow.

The pygidium is triangular in outline, the breadth rather more than two-and-a-half times the length, with a steeply declined border and a bluntly-pointed tip. The axis is poorly defined, particularly posteriorly where it merges gradually with the pleural lobes, the inner parts of which are swollen at that point. There are five narrow (*sag.*) axial rings, between the first and second of which is sited a pair of small apodemal pits. The pleural lobes have not been found well preserved, but there appear to be only two furrows on each, and they are developed only in the slightly tumid outer portion.

HORIZONS AND LOCALITIES. The holotype was obtained from the middle portion of the Marshbrookian Stage, the *Dalmanella unguis* Beds or Zone, which forms the upper half of the quarry face in the small, disused quarry by the west side of the track through Marsh Wood, half a mile south of Marshbrook Station. The species occurs also in the lower half of the same quarry face, made up of the *Dalmanella wattsi* Beds, the lowest subdivision of the Marshbrookian. At both these horizons the species is not uncommon, and other localities include the south bank of the River Onny 160 yards east of the eastern end of Burrells Coppice, near Horderley; the edge of the field 340 yards north-west of Maplewall Cottage, near Woolston; the exposure 685 yards east-south-east of Cwm Head Farm; the lane-section about 400 yards south-south-east of Soudley Quarry, between Hope Bowdler and Ticklerton; and the stream-section 550 yards south-south-west of Common Farm, Wallsbank. According to Bancroft (1929*a* : 91) *B. transiens* is found only in the middle subdivision of the Marshbrookian, but it is now known from both the lowest and highest beds. In the uppermost third of the Stage, known variously as the *Onniella reuschi* or *Kjerulfina polycyma* Zone, it is found much less abundantly than at lower horizons. Localities at this level include the west side of the track just south of Marsh Wood Quarry (see above); the west side of the road 20 yards west-north-west of Maplewall Cottage, near Woolston; and by the south bank of the River Onny 1050 yards west-south-west of Wistanstow Church. *B. transiens* is characteristic of the Marshbrookian Stage in south Shropshire, and outside the county has been recorded only from the Cross Fell Inlier, apparently at the same general horizon. This paucity of occurrences is probably the result of the general absence of Marshbrookian strata.

HOLOTYPE. BM. In. 42071.

FIGURED SPECIMENS. BM. In. 49129 (Pl. 18, figs. 12, 13); BM. In. 50594 (Pl. 18, fig. 7): BM. In. 50602 (Pl. 18, fig. 14); BM. In. 50604 (Pl. 18, fig. 8); BM. In. 52050 (Pl. 18, fig. 3); BM. In. 54001 (Pl. 18, figs. 2, 11).

DISCUSSION. Of all the other Shropshire trinucleids *B. transiens* bears most resemblance to *B. longiceps*, with which it shares a similar fringe form and pitting, together with the frequent persistence of coarse reticulation on the cheek-lobes of numerous adult specimens. The glabella of *B. transiens* is, however, usually shorter and more swollen anteriorly, and the pit-count for a mature cephalon is much smaller. Both species have a similar number of auxiliary pits in E_2, but whereas those of *B. transiens* are situated anterolaterally, those of *B. longiceps* are much closer to the genal angle. On the underside of the fringe of *B. transiens* the presence of closely-set pits of E_{1-2} in radial sulci is a feature not yet seen in mature cephala of the Upper Longvillian species, though a suggestion of it has been found in an immature specimen.

***Broeggerolithus* cf. *transiens* (Bancroft)**

(Pl. 18, fig. 9)

The Bancroft Collection at the British Museum (Natural History) contains a small number of specimens from a temporary excavation, a well digging, made in the Marshbrookian strata of the Wistanstow district. They include three mature cephala belonging to *Broeggerolithus*, the largest having a maximum breadth of 21 mm. The form represented appears to agree closely with *Broeggerolithus transiens* (Bancroft) but small differences between the two are found ; these include a slightly larger pit-count than the *forma typica*, a smaller number of pits in E_2, a general lack of auxiliary pits in E_2 and I_3, and a larger number of small pits in the area of the fringe internal to I_3. One specimen, BM. In. 52823, 20 mm. broad, possesses a twinned pair of pits in E_{1-2} near the left anterolateral angle, and has the fringe notation : E_1 0–20, E_2 0–19 ; e_1 xviii ; I_1 0–20, I_2 0–18, I_3 11–19, I_4 16–19 ; i_1 xx, i_3 xix, i_4 xv, xix. I_5 consists of three small pits rather irregularly arranged.

The best-preserved cephalon shows coarse reticulation on the surface of the glabella, but it is not clear whether this persists on the cheek-lobes. The species may prove to be specifically distinct from *B. transiens*, but in view of the limited material available it seems more advisable to compare it with that form.

HORIZON AND LOCALITY. The label attached to the specimens by Bancroft described them as coming from a " well-digging at the first house along the road south from The Corner ". The Corner is a hamlet situated about one and a quarter miles almost due north of Wistanstow Church, and the road referred to runs from the western end of the hamlet towards Wistanstow. The date of Bancroft's label is unknown, and it does not state from which side of the road his specimens originated, but it may be noted that the 6-inch Ordnance Survey map indicates a well by the west side of the road 200 yards south-south-east of the right-angle in the road which gives The Corner its name. The map does not show any other well along this stretch of road. The rock itself is a yellowish-grey, hard, calcareous mudstone and the associated fauna includes *Kjerulfina polycyma* Bancroft, indicating the *Onniella reuschi* Zone, the topmost subdivision of the Marshbrookian Stage. No surface exposures of rock have been found at The Corner itself, but field-mapping of the area by the writer confirms that rocks of high Marshbrookian age are, in fact, present underneath the hamlet.

FIGURED SPECIMEN. BM. In. 52823.

Genus *ONNIA* Bancroft, 1933

Bancroft's original diagnosis of the genus was brief and unsatisfactory, stating merely that *Onnia* "differs from the other genera of the subfamily in having the external spine-channel continuous with E_2, in the large number of pits in that row and their regularly concentric arrangement. I_4 is always present on the side of the cheek" (1933 : 2). Whittard (1958 : 88, 89), in discussing the genus *Broeggerolithus*, has suggested that it might be congeneric with *Onnia* on account of the two having in common a superficially similar fringe with two continuous rows of pits external to the girder, the differences between the two genera being confined to what he considers unimportant features. The present study of Caradoc trinucleids tends to confirm Bancroft's separation of *Onnia* from *Broeggerolithus*, and an attempt is made below to enumerate the features found most constant and useful in distinguishing the two.

Onnia	*Broeggerolithus*
E_1 and I_1 consist of pits mostly of equal size and larger than those of adjacent rows.	Only one row of larger pits, E_1 in Group 2, and I_1 in Group 3.
E_1 and I_1 are raised above neighbouring rows.	In Group 2, E_1 is raised, but the fringe is flat in the other groups.
Radial arrangement is strong, but no interradial ridges developed.	Group 2 has strongly developed interradial ridges, which are found on a smaller scale in Gp. 3, but not in Gp. 1.
Radii straight, found almost as far as the genal angles, and never flexed forwards.	Radii frequently flexed strongly at the line of the I_{1-2} pseudogirder.
Auxiliary pits numerous and regular in all parts of E_2.	Auxiliary pits never numerous, and usually restricted to one limited part of the fringe, except in *B. harnagensis*, when they are often irregularly arranged out of concentric line.
E_2 always complete anteriorly, and only rarely is a pit absent at the genal angle.	Several pits may be absent from E_2, both anteriorly and at the genal angle.
I_3 and I_4 are well developed, extending from as far forwards as R3 and R8 respectively.	I_3 not known farther forwards than R10, and I_4 usually consists only of a few pits.
Several pits of I_{2-4} are set in radial sulci.	Radial sulci rarely developed.
Genal spines long, more or less continuous with the lateral margins.	Genal spines short or of moderate length, often markedly splayed at an angle to the lateral margins.

In addition it may also be noted that in *Onnia* the " ears " of the fringe are always large, whilst in *Broeggerolithus* (*s.s.*) they are typically small, though becoming larger in species of Group 3, the stratigraphically younger forms.

Distribution. The appearance of *Onnia*? *cobboldi* (Bancroft) is used to define the base of the Onnian Stage, or *Onnia* Beds, in south Shropshire where the genus ranges upwards throughout the Stage. The horizontal distribution of *Onnia* throughout the Caradoc Area cannot be assessed owing to lack of outcrops. Two of the species usually assigned to the genus, *O. gracilis* and *O. superba*, are known also from the Cross Fell Inlier, and *O. gracilis* is found at Welshpool. Extra-British occurrences include *O. ornata* (Sternberg) in Bohemia and Portugal, and *O. cobboldi* has been reported from North Africa (G. & H. Termier, 1950 : 22). Another form possibly referable to *Onnia* comes from southern Norway. An alleged member of the genus has been figured from Venezuela as *O. terryi* (Leith) by Whittington (1954), but this identification cannot be upheld and the writer agrees with Whittard's view (1958 : 89) that the species is probably best placed in *Salterolithus*, at least for the time being, though a new generic name may eventually prove necessary. Another record of *Onnia* from South America (Rusconi, 1956 : 9) is also thought to be incorrect.

It has been found more convenient to group together the discussions of the various Shropshire Onniae at the end of this chapter, after the account of *Onnia superba*.

TYPE SPECIES. *Cryptolithus superbus* Bancroft, 1929, by original designation of Bancroft (1933 : 2).

Onnia? cobboldi (Bancroft)

(Pl. 19, figs. 1, 3, 12)

1929*a*. *Cryptolithus cobboldi* Bancroft, p. 92, pl. 2, figs. 6, 7.
1933. *Onnia cobboldi* (Bancroft) Bancroft, table 1.
1940. *Onnia cobboldi* (Bancroft) : Whittington, p. 245.
1948. *Onnia cobboldi* (Bancroft) : Lamont, p. 418, pl. 1, figs. 6–8.
1949. *Onnia cobboldi* (Bancroft) : Bancroft, p. 299, pl. 9, figs. 10, 11.
1958. *Onnia cobboldi* (Bancroft) : Dean, pl. 26, fig. 14.

DESCRIPTION. The cephalic outline is well rounded in front, forming more than half a circle, the posterolateral margins converging forwards from the bases of the genal spines which are situated at the extremities of moderately large " ears ". The greatest breadth occurs across the genal angles and is about equal to the total length of the complete exoskeleton, and almost twice the median length of the cephalon. The glabella is pear-shaped, swollen anteriorly, and stands high above the cheek-lobes, culminating in a median ocellus situated at its apex. In some specimens where the shell material is slightly translucent three pairs of dark muscle-scars show through ; the first of these comprises large scars, but the others decrease in size rearwards, and the third pair almost coincides laterally with a pair of shallow pits situated just inside the axial furrows and in front of the occipital furrow. The axial furrows are broad and shallow, with small hypostomal pits situated well forwards, and only slightly convex outwards, bordering moderately swollen cheek-lobes. The occipital furrow is shallow medially but deepens laterally where a pair of occipital pits is sited ; the occipital ring is short, produced upwards and backwards into a slim occipital spine. The pleuroccipital furrow and segment are narrow (*exsag.*), the former only moderately deep, and extend to the fulcral sockets which are situated less than halfway from the axial furrows to the lateral margin. Beyond the fulcral sockets the posterior margins of the fringe are straight, directed slightly rearwards to the genal angles so as to enclose " ears " of moderate size. The genal spines, which are at least slightly longer than the cephalon (*sag.*), are not quite continuous with the lateral margins of the cephalon ; each carries a longitudinal groove on its upper surface, a longitudinal ridge on its lower surface and becomes slightly incurved towards the tip. The marginal suture, of normal trinucleid type, runs just below the top of the moderately declined border and clearly demarcates the smooth surface of the upper lamella from that of the lower lamella which, together with its genal spine, carries well-defined, closely grouped terrace-lines.

The fringe is of moderate width with three continuous rows of pits E_{1-2} and I_1, narrowing slightly in front of the glabella, the encroachment of which is accommodated by the absence of a few pits, generally four, of I_2. E_1 and I_1 consist of larger, usually more polygonal pits than the other rows, and both of them, though generally more particularly E_2, are slightly raised above the level of the rest of the upper lamella. E_2 contains slightly smaller pits, together with a few auxiliary pits distributed fairly uniformly. I_3 and I_4 are well developed, though occasional pits are completely absent from the latter row. In cephala of young individuals radial sulci are found which contain pits of I_{1-4}, but in the adult and in a cephalon 10 mm. wide, the pits of I_1 are larger and bordered on their inner side by a concentric I_{1-2} ridge separating them from the radial sulci which now include only pits of I_{2-4}. The number of pits present in the adult trilobite is $E_2 = 18$–24 (mode $= 22$), $E_1 = 18$–21 (mode $= 19$), $I_1 = 18$–22 (mode $= 19$), $I_2 = 16$–19 (mode $= 17$), $I_3 = 13$–16 (mode $= 14$). Fewer specimens with well-preserved I_4 have been found, but apparently the usual number of pits present is 10. These figures are based on material from the type-locality. The holotype itself is insufficiently preserved for its fringe notation to be written in full, but for a typical large adult specimen, BM. In. 49026, 25 mm. wide and 10·5 mm. long medially, it is E_1 1–19, E_2 1–18 ; e_2 o, iii, viii, xiv ; I_1 1–18, I_2 3–19, I_3 8–17, I_4 10–12, 15, 16, 18 ; i_1 xvii, i_2 xvii, i_3 xiii, xvii. The underside of the fringe carries a girder which is only moderately developed, and an I_{1-2} pseudogirder which is poorly defined.

The thorax contains six typically trinucleid segments, the first of them macropleural ; the third and fourth segments are the widest (*tr.*), the outline of the thorax then narrowing slightly towards both cephalon and pygidium. The axis occupies about one-quarter of the total breadth, is bounded by poorly-defined axial furrows, and is not markedly convex above the side-lobes. Each pleura is smooth apart from a pleural furrow which commences at the front edge coincident with the axial furrow and runs straight outwards and slightly backwards to the backwardly-directed, slightly turned-down pleural point. The pleura is thus divided into two bands, of which the posterior is the larger.

The pygidium is roughly triangular in plan, the length being about one-third of the maximum breadth, which is also approximately equal to the length of the cephalon. Frontally the triangular axis occupies one-quarter of the breadth, is delimited by very shallow axial furrows, and merges gradually with the side-lobes. Each axial ring possesses two pairs of muscle-scars which show through the test as small dark patches ; the inner pair is situated slightly in front of the outer pair which is located almost on the lines of the axial furrows. Only six axial rings have been seen, but there are eight sets of muscle-scars, extending almost to the tip of the axis. Each side-lobe has a small raised marginal rim and usually five pleural furrows which decrease in depth from first to last ; the pleurae so formed are continuous with their corresponding axial rings. The pygidial border is steeply declined, becoming shallower towards the tip, and covered with closely-crowded terrace-lines parallel to the marginal rim.

HORIZON AND LOCALITIES. The type-locality is in the bed of the River Onny by the south bank, about 45 yards east-south-east of the point where Batch Gutter joins the river. The species occurs also at various other points in the vicinity of the type-locality, particularly the north bank of the Onny 63 yards east-south-east of its junction with Batch Gutter, and is found throughout a thickness of about forty feet of rock. *Onnia*? *cobboldi* marks the lowest subdivision, the zone to which it gives its name, of the Onnian Stage, and is accompanied by abundant *Onniella inconstans* Bancroft with occasional *Platylichas* and *Chasmops*. Owing to the lack of exposures the species is not encountered in south Shropshire outside the Onny Valley and has not yet been found elsewhere in Britain.

LECTOTYPE, here selected. BM. In. 42072, a cephalon figured by Bancroft (1929*a*, pl. 2, fig. 6).

PARATYPE. Bancroft's other syntype (1929*a*, pl. 2, fig. 7), a pygidium, has not yet been traced.

FIGURED SPECIMENS. BM. In. 49026 (Pl. 19, figs. 3, 12) ; BM. In. 49028 (Pl. 19, fig. 1).

Onnia gracilis (Bancroft)

(Pl. 19, figs. 2, 7)

1929*a*. *Cryptolithus gracilis* Bancroft, p. 94, pl. 2, figs. 8, 9.
1933. *Onnia gracilis* (Bancroft) Bancroft, table 1.
1938. *Cryptolithus gracilis* Bancroft : Shackleton, p. 455.
1940. *Onnia gracilis* (Bancroft) : Whittington, p. 245.
1948. *Onnia gracilis* (Bancroft) : Lamont, p. 418, pl. 1, fig. 9.
1949. *Onnia gracilis* (Bancroft) : Bancroft, p. 299, pl. 9, fig. 9.
1958. *Onnia gracilis* (Bancroft) : Dean, p. 212, pl. 26, fig. 15.

DESCRIPTION. The cephalic outline is generally well rounded, nearly a semicircle, often slightly subangular frontally. The glabella is roughly pear-shaped, swollen anteriorly, stands moderately high above the cheek-lobes, and has a distinct median ocellus. Basal glabellar furrows are represented by a pair of small apodemal pits, in front of which two pairs of flattened ovoid impressions or muscle-scars may be seen in well-preserved specimens. The axial furrows are deep, broad, gently convex outwards, and contain hypostomal pits of moderate size near their anterior ends. Numerous cephala with the test intact have been examined, but none shows the group of large punctae immediately in front of each hypostomal pit such as is described elsewhere in this paper from *Onnia superba* and *Broeggerolithus harnagensis*?. The axial furrows border convex cheek-lobes, the surface of which is smooth in the adult trilobite but reticulate in immature cephala at least up to about 8 mm. wide.

The occipital furrow is broad (*sag.*) and shallow, with a pair of deep occipital pits near its outer ends, and the small occipital ring is produced backwards and upwards to form a short occipital spine. The pleuroccipital furrow is shallow and fairly broad (*exsag.*) ; both it and the narrow (*exsag.*) pleuroccipital segment follow a gently sigmoidal course to the fulcral sockets, situated just less than half-way from the axial furrows to the lateral margins. Beyond the fulcral sockets the posterior margins of the fringe are convex rearwards, directed outwards and backwards to the genal spines so as to form large " ears ". The genal spines are continuously in line with the lateral margins of the fringe and irregularly quadrilateral in cross-section, each of the four sides having a longitudinal groove developed to a varying degree. The attitude of the cross-section is such that one of the grooved sides is uppermost, continuous with the surface of the upper lamella, whilst one of the ridges runs longitudinally along the underside of the spine continuous with the girder.

The cephalic fringe is broad, becoming narrower in front of the glabella where four rows of pits, E_{1-2} and I_{1-2}, are continuous, and markedly broader posterolaterally where it expands rapidly behind the cheek-lobes. Frontally the pits of all the four rows present are of similar size except those of E_1, which are much larger, but laterally the pits of I_1 expand to the same large size whilst those of the other rows remain small. Both E_1 and I_1, particularly the former, are raised slightly above the level of the other rows. E_2 extends to the genal angle and consists of very small pits, numerous and crowded together so that the strong radial arrangement which extends outwards from I_4 to E_1 inclusive is only poorly developed. I_3 and I_4 are both well developed, extending from as far forwards as R3 or R4 and R10 or R11 respectively. The pits of I_{2-4} are set in slightly depressed radial sulci over the anterolateral and lateral portions of the fringe, but these, together with the marked radial arrangement of fringe pits in general, extend usually only as far as about R20, beyond which point there is a more random arrangement of pits near the posterior margin. The number of pits present in each of the concentric rows is as follows, the figure in brackets representing the mode. $E_2 + e_2 = 31$–37 (34), $E_1 + e_1 = 21$–25 (22), $I_1 + i_1 = 21$–25 (22), $I_2 + i_2 = 21$–25 (23), $I_3 + i_3 = 17$–23 (20), $I_4 + i_4 = 13$–18 (16).

The pits along the posterior margin of the fringe number from 8–11, though more commonly 9. The fringe notation for the lectotype cephalon is E_1 0–22, E_2 0–22 ; e_1 xxi, xxii, e_2 0, ii, iii, vi, viii, xi, xiii, xv, xvii, xx, xxii ; I_1 0–22, I_2 0–22, I_3 4–22 ; I_1 xxi, i_2 xxi, xxii, i_3 xxi, xxii ; $I_4 + i_4$ consists of about 17 pits, radially arranged from R10 to R20 but then becoming irregularly disposed ; $I_5 + i_5$ consists of 5 pits irregularly arranged, but forming a well-defined line at and behind the posterolateral part of the cheek-lobe.

On the lower lamella of the fringe is a poorly-marked girder together with two pseudogirders situated I_{1-2} and E_{1-2}. All these concentric ridges are developed to about the same degree, and the girder appears to coalesce with the outer pseudogirder near the genal angle just before running into the longitudinal ridge of the genal spine. The I_{1-2} pseudogirder extends only to the more random group of pits beyond about R20 mentioned earlier and does not attain the posterior margin of the fringe. Each girder or pseudogirder carries a narrow band of three or four terrace-lines along its length. Closely-grouped terrace-lines are found also on that portion of the moderately-declined cephalic border below the line of the marginal suture. The cephalon of the paratype, a whole individual (Pl. 19, fig. 7), has apparently been damaged during the life-time of the animal and subsequently healed. The upper lamella is broken off diagonally near the genal angle, so that E_1 extends only as far as R18. The damaged portion of the fringe is not quite complete, but the posterior margin appears to have regenerated along the broken edge, and there is now no sign of the course of the marginal suture which normally cuts the posterior margin at roughly its mid-point.

The thorax contains six thoracic segments, the first of which is macropleural. The greatest breadth occurs across the third, fourth and fifth segments, to the front and rear of which the outline narrows slightly. The thoracic axis is narrow, about one-fifth of the total breadth, stands moderately high above the side-lobes, and is bounded by broad, shallow, poorly-defined axial furrows. In addition to the articulating furrow each segment carries a median transverse furrow on the axial ring, moderately deep at the axial furrows but almost obsolete medially. Each pleura has a strong pleural furrow which commences at the intersection of the anterior margin and the inner boundary of the axial furrow, and then runs outwards and backwards towards the pleural tip which ends posterolaterally in a backwardly-directed point. The pleural furrow becomes deeper and broader (*exsag.*) outwards, and divides the pleura into two bands, of which the anterior is the smaller.

The pygidium is subtriangular in outline, roughly three times as broad as long, with a narrow, well-defined, convex axis occupying rather less than one-sixth of the frontal breadth and extending to the tip of the pygidium. Axial rings are numerous, usually about nine, with two pairs of small, dark muscle-scars situated in each axial furrow. The side-lobes each have seven or eight pleurae, becoming less well defined rearwards, the first two or three of which carry traces of rib furrows. The steeply-declined border is ornamented with terrace-lines and topped by a raised marginal rim.

HORIZON AND LOCALITIES. The type-specimens are from the ledge-like bed of calcareous grey mudstone running north-north-east across the River Onny 100 yards east of the junction of the river and Batch Gutter, south-west of Wistanstow. The species is abundant there, but occurs both above and below this level throughout a thickness of about 60 feet of rock marking a zone within the Onnian Stage or *Onnia* Beds. No other occurrences of the species are known from south Shropshire, but *Onnia gracilis* is abundant in the Cross Fell Inlier and is known from the Gwern-y-brain Shales of Welshpool.

LECTOTYPE, here selected. BM. In. 42074 (Pl. 19, fig. 2). An incomplete cephalon with the test preserved, figured previously by Bancroft (1929*a*, pl. 2, fig. 8) and Dean (1958, pl. 26, fig. 15).

PARATYPE. One of the syntypes figured by Bancroft (1929*a*, pl. 2, fig. 9) showed merely a pygidium, not quite complete, with a fragment of some thoracic segments close by. It is now plain that the figure in question showed only a portion of a whole individual, BM. In. 49032, which is here figured in its entirety (Pl. 19, fig. 7).

Onnia superba (Bancroft)

(Pl. 19, figs. 4–6, 8, 9, 11, 13, 14)

1839. *Trinucleus caractaci* Murchison, pl. 23, figs. 1 d–f only.
1854. *Trinucleus concentricus* Eaton : Murchison, pl. 4, fig. 3 only.
1859. *Trinucleus concentricus* Eaton : Murchison, pl. 4, fig. 3 only.
1867. *Trinucleus concentricus* Eaton : Murchison, pl. 4, fig. 3 only.
1872. *Trinucleus concentricus* Eaton : Murchison, pl. 4, fig. 3 only.
1884. *Trinucleus concentricus* (Eaton) : La Touche, pl. 3, fig. 55.
1912. *Trinucleus concentricus* (Eaton) : Reed, pp. 347, 349, 351, pl. 18, figs. 1, 4, 7, 12.
1912*a*. *Trinucleus concentricus* (Eaton) : Reed, p. 387.
1914. *Trinucleus concentricus* (Eaton) : Reed, p. 355, pl. 29, figs. 3, 3a.
1929*a*. *Cryptolithus superbus* Bancroft, p. 95, pl. 2, fig. 10.
1933. *Onnia superba* (Bancroft) Bancroft, p. 2, table 1.
1940. *Onnia superbus* (Bancroft) : Whittington, p. 245.
1948. *Onnia superba* (Bancroft) : Lamont, p. 418, pl. 1, figs. 1–5.
1949. *Onnia superba* (Bancroft) : Bancroft, p. 299, pl. 9, fig. 12 ; pl. 10, fig. 16.
1958. *Onnia superba* (Bancroft) : Whittard, p. 88.
1958. *Onnia superba* (Bancroft) : Dean, p. 212, pl. 26, fig. 16.

DESCRIPTION. The cephalic outline is usually subangular both frontally and anterolaterally, the maximum breadth being slightly more than twice the median length, excluding the occipital spine. The glabella is high, swollen anteriorly and generally rather narrow, though this often appears exaggerated owing to crushing ; it encroaches on the fringe and is accommodated by the flexing forwards of E_1 and I_1, and the absence of a few pits of I_2. Glabellar furrows are represented only by one pair of small, basal apodemal pits. The cheek-lobes are smooth, quadrant-shaped, moderately convex, and separated from the glabella by fairly deep, gently curved axial furrows. Each furrow has a deep hypostomal pit situated well forwards, and between this and the pits of the cephalic fringe there have been found, in a few better-preserved specimens, all of them internal moulds with a limonitic replacement of the test, a series of small punctae which are just visible under a hand lens. These, the function of which is not yet apparent (but see p. 106), begin just outside the line of the hypostomal pit and extend inwards covering a small rectangular area about 1 mm. long (*tr.*) ; in one or two of the specimens there appear to be about six or seven rows, each with three punctae. The occipital furrow is only moderately deep medially, becoming still shallower laterally where a pair of occipital pits is sited, marking the small occipital ring which is directed backwards and upwards, and produced to form a small occipital spine. The shallow pleuroccipital furrow and narrow (*exsag.*) pleuroccipital segment run straight out from the axial furrows to the fulcral sockets, about halfway to the lateral margins ; beyond the fulcral sockets the posterior margins of the fringe turn back sharply towards the bases of the genal spines, so as to form large " ears ". The genal spines are long, the longest known being almost three times the median length of the cephalon, and continue along the lines of the lateral margins of the cephalon. The upper surface of each spine is longitudinally grooved, the underside has a median ridge continuous with the girder, and the tip is gently incurved.

The cephalic fringe is wide posterolaterally, narrowing in front of the glabella where only the three outermost rows of pits, E_{1-2} and I_1, are complete. The marginal suture is of the usual trinucleid type and there is a small, raised marginal rim. The pits of E_1 and I_1 are noticeably larger and more polygonal than those of adjacent rows, and become still larger posterolaterally ; the two rows are raised above the surface of the remainder of the upper lamella. A concentric ridge is developed between E_1 and I_1, and the raised portion of the upper lamella is separated from the rest by similar ridges situated E_{1-2} and I_{1-2}. The outermost row, E_2, is conspicuous on account of the smallness of its pits and the presence of several auxiliary pits distributed along its entire length, which extends to the genal angle. The area internal to the ridge separating I_1 and I_2 is particularly noteworthy for the development there of interradial ridges, lower than E_1 and I_1, between which the pits of I_{2-4} are sunk in radial sulci ; the interradial ridges commence about R7 or R8 and extend as far as about R15 or R16. The number of pits present in each of the four outermost concentric rows is $E_2 + e_2 = 25$–28 (mode = 27 or 28), $E_1 + e_1 = 16$–19 (mode = 18), $I_1 + i_1 = 18$–21 (mode = 19), $I_2 + i_2 = 16$–20 (mode = 17). The fringe of the holotype is not completely preserved, so that it is impossible to write the pit notation, but a typical large adult specimen, BM. In. 52089, 23 mm. wide, exhibits the following pattern E_1 1–18, E_2 1–18 ; e_2 0, vii, ix, xiii, xv, xvii ; I_1 1–18, I_2 3–18, I_3 7–18, I_4 13–18 ; i_1 xv, i_2 xv, xvii, i_3 xv, xvi, xviii, I_4 xv, xvi, xvii. The number of pits along the posterior margin of the fringe is usually seven or eight. The ventral surface of the fringe possesses a well-developed girder which follows the bluntly angular outline of the cephalon frontally and diminishes considerably beyond the anterolateral angles. An I_{1-2} pseudogirder is also found, but is only significant laterally and posterolaterally.

The thorax consists of six typically trinucleid segments, the first macropleural. The thoracic axis, roughly one-quarter of the total breadth, is bounded by shallow, almost straight, subparallel axial furrows. The internal mould of each axial ring carries a moderately deep articulating furrow, at either end of which, just inside the axial furrow and bordering a small axial node, is a deep apodemal pit. Each pleura is flat, divided into two bands by a pleural furrow which commences at the anterior edge just outside the axial furrow and runs outwards and backwards to the blunt, backwardly-directed pleural point, in the vicinity of which it becomes slightly deeper.

The pygidium is subtriangular in outline, with a border steeply declined over most of its length, becoming less so at and near the bluntly-pointed posterior termination. Frontally the axis occupies about one-fifth of the maximum breadth ; it is triangular in plan, bounded by shallow axial furrows, stands moderately high above the pleural lobes, and extends to the tip of the pygidium. The first axial furrow is marked laterally by a pair of small, slot-like apodemal pits, but thence to the posterior tip of the axis there are several axial rings, usually up to eight or nine, which are poorly defined. The pleural lobes are flat, bounded by a small, bevelled, raised rim, and each carries a series of pleural furrows continuous with the ring furrows. The pleural furrows are badly defined on the internal mould, becoming less distinct towards the tip of the pygidium, and even on the external mould only the first two pairs of furrows are at all clearly marked.

IMMATURE INDIVIDUALS. The mudstones at the type-locality of *Onnia superba* have yielded several specimens of the young of the species. Unfortunately their presence as disarticulated cephala makes it impossible for the various degrees of development to be worked out in detail, nevertheless, something can be learned of the successive changes in the form of the cephalon.

The smallest cephalon available, BM. In. 50701, is 2·5 mm. wide and about 1·0 mm. long. Its preservation is poor, but it shows three rows of pits in front of the glabella, and a pair of short (*tr.*) ocular ridges which run outwards and slightly backwards from the glabella just in front of its midpoint, crossing the axial furrows. The characteristics of larger cephala are enumerated in semi-tabular form below.

Cephalic Length (mm.)	Cephalic Breadth (mm.)	Characteristics
1·25–1·5	3·5–3·75	E_{1-2} complete, I_1 almost complete. Cheek lobes reticulate. Ocular ridges and median ocellus present. Alar lobes developed, about half the length of the glabella, triangular in form, bounded on the outside by the axial furrows, on the inside by the shallow alar furrows, and posteriorly by the occipital furrow.
1·8	4·0	Ocular ridges less well developed. Alae slightly smaller and narrower. I_2 developed as far forwards as R3. Pits present : $E_2 + e_2 = 23$, $E_1 + e_1 = 18$, $I_1 + i_1 = 19$, $I_2 + i_2 = 16$.
2·0	5·0	Reticulate cheek-lobes. Ocular ridges poorly developed. Alae shorter and more rounded. Occipital spine more conspicuous. Pits of E_1 and I_1 noticeably larger. Traces of radial sulci in I_{2-3}. I_2 from between R2 and R5, I_3 from R7. $E_2 + e_2 =$ 23–27 pits, $E_1 + e_1 =$ 19–20, $I_1 + i_1 =$ 18–19, and $I_2 + i_2 =$ 15–18.
2·3–2·5	5·5–6·0	Cheek-lobes reticulate. No ocular ridges seen. Median ocellus present. Alae are indistinct swellings, poorly defined. $E_2 + e_2 = 24$ pits, $E_1 + e_1 = 18$, $I_1 + i_1 =$ 17–19, $I_2 + i_2 =$ 17–18. I_2 developed from R3, and I_3 from R5 or R7.
3·8–4·0	8·0–8·5	Median ocellus present. One specimen with strong occipital spine half the length of the glabella. Cheek-lobes reticulate. $E_2 + e_2 =$ 22–23 pits, $E_1 + e_1 = 18$, $I_1 + i_1 = 18$, $I_2 + i_2 =$ 16–19, I_2 developed from about R2, I_3 from R7, and I_4 from R12. Alae not developed.
4·0	9·5	Cheek-lobes reticulate. Number of pits present much the same as in previous group, with one or two more in E_2.
5·5	12·0	Cheek-lobes reticulate. E_1 and I_1 comprise larger pits and raised above adjacent rows. $E_2 + e_2 = 28$ pits, $E_1 + e_1 = 20$, $I_1 + i_1 = 20$, $I_2 + i_2 = 21$.
6·0	13·0	Reticulation of cheek-lobes less pronounced. Six thoracic segments present, and this is the youngest holaspid known with certainty. The general appearance, and number of pits present in the four outermost rows much the same as in larger adults. $E_2 + e_2 = 27$ pits, $E_1 + e_1 = 19$, $I_1 + i_1 = 20$, $I_2 + i_2 = 16$. I_3 developed from R7, I_4 from R11, and radial sulci found in I_{2-4}.

Horizon and locality. The type-locality is the small cliff formed by yellow-weathering mudstones in the north bank of the River Onny 160 yards east of the junction of the river and Batch Gutter, and 720 yards west-south-west of Wistanstow Church. The place has been known to many generations of geologists as " The Onny Section ", and has been the source of almost all the specimens of *Onnia superba* collected from Shropshire. The species occurs there in great profusion, and entire adult individuals are by no means rare. *O. superba* occurs throughout a thickness of about fifty feet of rock, including strata, found only in the river bed, below and above those exposed in the main cliff section, and marks the topmost subdivision or zone of the Onnian Stage. Elsewhere the species has only been recorded from the Cross Fell Inlier.

Holotype. BM. In. 42070, a nearly complete cephalon preserved as an internal mould.

Figured specimens. BM. In. 42070 (Pl. 19, fig. 9) ; BM. In. 49029 (Pl. 19, figs. 13, 14) ; BM. In. 49030 (Pl. 19, fig. 11) ; BM. In. 49157 (Pl. 19, fig. 6) ; BM. In. 49158 (Pl. 19, figs. 4, 5) ; BM. In. 50709 (Pl. 19, fig. 8).

Onnia aff. ***superba*** (Bancroft)

(Pl. 19, fig. 10)

In association with the extremely abundant specimens of *Onnia gracilis* found at the type-locality of that species there occurs rarely another form of *Onnia* which bears a general resemblance to *Onnia superba* and is probably related to it.

The cephalic outline is fairly well rounded frontally and slightly subangular anterolaterally. The glabella is slightly clavate anteriorly, has a small median ocellus, and stands high above the only moderately convex cheek-lobes ; through the translucent calcite of the test can be seen three pairs of dark muscle-scars, the first and third pairs small, the second pair much larger, and between the basal pair of scars and the occipital furrow is a pair of very small apodemal pits. The axial furrows are almost straight, broad, and moderately deep. The occipital furrow is shallow and poorly defined, and the small occipital ring is produced to form a small occipital spine. The pleuroccipital furrow and segment are both narrow (*exsag.*) and gently sigmoidal as far as the fulcral sockets which are situated less than halfway from the axial furrows to the lateral margins. The fringe is fairly broad posterolaterally, but narrows frontally where only three concentric rows of pits are continuous in front of the glabella. The pits of E_1 are larger than those of the other rows except posterolaterally, where the pits of I_1 attain a comparable size. E_1 and I_1 are both separated and delimited by slightly raised concentric ridges, and the portion of the fringe occupied by both rows is elevated above the remainder of the fringe. E_2 consists of numerous small pits and extends to the genal angle, whilst the pits of I_{2-4}, also small, are set in radial sulci posterolaterally. The fringe notation for the figured, and best-preserved, specimen is E_1 1–21, E_2 1–21 ; e_2 0, iii, x, xv, xvii, xix, xxi ; I_1 1–21, I_2 4–21, I_3 8–16, 18–22, I_4 13–22. There is a triangular group of pits between I_1 and I_2 at the posterior margin of the fringe, and there are eight pits situated along the posterior margin of the fringe.

The thorax and pygidium are unknown.

HORIZON AND LOCALITY. The north bank of the River Onny 100 yards east of the junction of Batch Gutter with the river. The exposure is at the northern end of the outcrop in the bed of the Onny which yielded the type-specimens of *Onnia gracilis*, and is at the same horizon.

FIGURED SPECIMEN. BM. In. 54037 (Pl. 19, fig. 10).

DISCUSSION. For the sake of convenience the various species assigned to *Onnia* in south Shropshire are discussed together here instead of individually.

The earliest form, *Onnia*? *cobboldi*, is only tentatively referred to *Onnia* as it exhibits certain features which are not typical of the genus in its restricted sense and which distinguish it from other Onniae, namely, a relatively long cephalon and general lack of auxiliary pits in E_2. Some individuals, though not all, do not have E_1 and I_1 elevated above the remainder of the upper lamella of the fringe. Such features are more characteristic of *Broeggerolithus*, especially in its stratigraphically later species, but against them must be set the possession of other features which are typical of *Onnia* (*s.s.*), viz. I_3 and I_4 are strongly developed, from R8 and R10 respectively, E_2 extends to the genal angle and I_2 is discontinuous in front of the glabella, as in the type-species of *Onnia*. The balance is therefore on the side of retaining the species *cobboldi* in *Onnia*, though with reservations. It is the first trinucleid found in south Shropshire after a long interval, represented stratigraphically by the Actonian Stage, in the otherwise fairly constant line of development within the group and when this gap in our knowledge has been filled it seems quite likely that *O.*? *cobboldi* may be found to be intermediate between the later members of *Broeggerolithus*, themselves somewhat transitional, and *Onnia* of the *superba* group. G. & H. Termier (1950, pl. 187, figs. 8–11) have figured what they call *Onnia cobboldi* from the Caradoc of Morocco, but, judging from their inadequate illustrations, the identification must be regarded as suspect.

Onnia gracilis, though occurring abundantly throughout the middle portion of the Onnian Stage, differs in several obvious respects from the other Shropshire Onniae. The cephalon of *Onnia gracilis* is proportionately much wider and shorter, E_2 consists of a large number of small pits, including numerous auxiliary pits, E_1 is usually more elevated than I_1 above the rest of the upper lamella, and I_2 is continuous in front of the glabella, a characteristic not seen in *O.*? *cobboldi* or *O. superba.* The Bohemian species *Onnia ornata* (Sternberg) shares all these features with *O. gracilis*, but differs in possessing a generally smaller number of fringe pits, and a cephalic outline in which the lateral margins of the adult trilobite are parallel or divergent forwards. The alar lobes of young individuals of *O. ornata* described by Whittington (1940) are not crossed by the occipital furrow, unlike those of *O. superba* in the present paper which are bordered posteriorly by the occipital furrow.

Onnia superba, like *O.*? *cobboldi* and unlike *O. gracilis* and *O. ornata*, has three continuous rows of pits in front of the glabella. It is readily distinguished, however, from the former species by the usually more angular cephalon, the much larger number of pits in E_2, including several more auxiliary pits distributed fairly evenly along all parts of the fringe, and by the large number of auxiliary pits in I_{2-4}. The incomplete cephalon figured by Størmer (1930 : pl. 6, fig. 13) as *Cryptolithus* cf. *portlocki* (Salter) shows several features, such as the possession of three continuous rows of pits frontally, the extension of E_2, which is composed of numerous small pits, to the genal angle, the presence in E_1 and I_1 of larger pits than in neighbouring rows, and the apparent existence of radial sulci internal to I_1, which suggest that it is actually an *Onnia*, probably related to *O. superba*. It appears to differ from the Shropshire species, however, in having a slightly higher pit count for at least the three outermost rows, but a more detailed comparison must await the examination of additional material.

The Norwegian species is interesting and important in that it extends the known range of *Onnia* both geographically and stratigraphically as the species, being associated with *Tretaspis latilimba* Linnarsson, is apparently from Stage 4cβ, an horizon at least approximately equivalent to the lower part of the Ashgill Series. In Britain no records of *Onnia* are known after the *Dicranograptus clingani* Zone, but the genus occurs with *Tretaspis* in the Onnian of the Cross Fell Inlier.

In the present paper the trinucleid figured as *Onnia* aff. *superba* (Pl. 19, fig. 10) is of particular importance on account of the horizon from which it was collected, the *Onnia gracilis* Zone. *O.* aff. *superba* differs from *O. superba* itself in having a few more pits in E_1 and I_1, but, like that species, has only three continuous rows of pits in front of the glabella compared with four in *O. gracilis* with which it is associated. It is possible, or even likely, that *O.* aff. *superba* represents a link between *O.*? *cobboldi* and *O. superba*, but more material of this rare form is needed.

It has been pointed out earlier (see p. 128) that the trinucleid from Venezuela assigned by Whittington to *Onnia* does not belong to the genus and is probably best regarded as a *Salterolithus*. Rusconi (1956 : 9, pl. 1, fig. 11) has also described a so-called *Onnia*, *O. verrucosa*, from the Mendoza district of Argentina. His only illustration is inadequate, but shows a short cephalon with conspicuous lateral ocelli just outside the axial furrows and a fringe which clearly bears no resemblance to that of *Onnia*. A detailed comparison must await further illustration of the species, but it seems fairly certain that a genuine *Onnia* has not yet been discovered in South America.

IV. THE DEVELOPMENT AND RELATIONSHIPS OF THE TRINUCLEIDAE IN SOUTH SHROPSHIRE

Bancroft's views on some of the Caradoc Trinucleidae were summarized briefly in a short paper (1935) in which the following opinions were expressed.

(*a*) There is a line of descent from *Marrolithus*, with no E_2 row, to *Reuscholithus*, with E_2 frontally and posterolaterally, by way of late Costonian forms (presumably those now termed *Costonia*) in which E_2 is developed frontally.

(*b*) Another line of descent is *Salterolithus* → *Ulricholithus* → *Broeggerolithus* → *Cryptolithus* (*s.s.*). Apparently Bancroft believed the first true *Cryptolithus* to be *C. tesselatus* Green, which he stated to occur in the Upper Longvillian of the U.S.A.

He drew attention to the fact that *C. tesselatus* differed from *Broeggerolithus soudleyensis* only in the complete absence of E_2, and implied that the latter species was ancestral to the former.

After examining numerous trinucleids from horizons throughout most of the Caradoc Series, the author agrees with certain features of Bancroft's claimed " lines of descent ", but cannot subscribe to others. In general, Bancroft's views appear to represent an over-simplification of the position, and current views on Caradoc correlations and trilobite distribution differ in many respects from those of even a few years ago. Knowledge of trinucleid evolution and distribution is still far from complete and the following remarks summarize the present position with regard to the Caradoc faunas of Shropshire.

There appear to have been at least three lines of trinucleid evolution during the Costonian Stage (late *Nemagraptus gracilis* Zone) in Shropshire. The first of these concerns for the most part the genus *Marrolithus*, which was abundant in the Anglo-Welsh Area throughout the Upper Llanvirn and Llandeilo Series and continued with little change into the Harnagian Stage (Spy Wood Grit) of the Shelve Inlier. The history of the group is unknown in south-east Shropshire until the topmost Costonian Stage, where the genus *Costonia* retains sufficient *Marrolithus*-like characters, such as subangular cephalic outline and anterolateral inflation of the fringe, to suggest that it represents a local offshoot from the main *Marrolithus* stem. As described earlier in this paper, the derivation of *Reuscholithus* from *Costonia elegans* appears to be comparatively straightforward, but no evidence has been found for the continuation of this line of development and *Reuscholithus* itself is probably earlier in age than the last-known members of the ancestral *Marrolithus* group in the Spy Wood Grit of the Shelve Inlier.

The earliest other trinucleids found in south Shropshire are *Broeggerolithus* (*s.l.*), *Salterolithus* and *Smeathenia*, all of which appear almost simultaneously in the early Harnagian Stage. Their pre-Harnagian history is as yet unknown, but *Broeggerolithus* is found west of Bala at what may be a slightly lower horizon, though this is not certain, so that its migration from still farther west is possible. Whether or not the three genera derived from a common ancestor such as *Lloydolithus*, to which *Salterolithus* bears some resemblance, from the base of the Harnagian onwards they represent two separate lines of evolution. On the one hand is *Broeggerolithus*, and on the other are the probably interrelated *Salterolithus* and *Smeathenia*. In the present work the former *Salterolithus harnagensis* is placed in *Broeggerolithus* (*s.l.*), and this Harnagian form probably developed into typical *Broeggerolithus* (*s.s.*) of the *broeggeri* type through *Broeggerolithus ulrichi* by means of : *a.* suppression of numerous auxiliary pits, some of them irregularly arranged, *b.* accentuation of straight, sometimes slot-like, radial rows of pits, *c.* formation of raised interradial ridges, especially in E_1, *d.* loss of some pits of E_2 at the genal angles, though this trend is partially reversed in the last-known species of *Broeggerolithus*, and *e.* stronger development of the pit walls compared with the size of pit, so as to form both radial and concentric " bands ". That the above account may yet prove to be an over-simplification is suggested by the fact that Harper (1956 : 386) has recorded *Salterolithus harnagensis* from near Llanystwmdwy, Caernarvonshire in company with

Broeggerolithus in which some pits of E_2 are absent frontally, but unfortunately no figures of this material are yet available for comparison.

The evolution of *Broeggerolithus* in the Lower Longvillian is interesting as there are three types present, viz.:—

1. It may be assumed that *B. soudleyensis* existed in south Shropshire during the Lower Longvillian, though it has not yet been found, as the species occurs in the Upper Longvillian virtually unchanged from the Soudleyan form. It has been recorded from the Lower Longvillian of the Berwyn Hills (Whittington, 1938*a* : 451), and its apparent absence from Shropshire is probably due to the development there of massive sandstones in the Lower Longvillian, representing an environment in which trinucleids do not occur so abundantly as in mudstones.
2. *Broeggerolithus globiceps* has a few pits of E_2 absent anteriorly, but other differences from *B. soudleyensis* are marked and the two species can only be distantly related, though possibly originating from an ancestral *B. broeggeri*.
3. *Broeggerolithus simplex* sp. nov., with its fully developed E_2, lack of a raised E_1, and much less well-developed interradial ridges, is reminiscent of the Upper Longvillian and Marshbrookian species, of which it may be the forerunner, and is distinct from *B. globiceps*.

The ensuing development of *Broeggerolithus* through the Upper Longvillian and Marshbrookian, with *B. longiceps* and *B. transiens* respectively, is reasonably straightforward and the latter shows, as the name implies, some features, for example the increase in the size of pits in E_1 and I_1, which might appear to mark a transition to the genus *Onnia*. However, such a transition cannot yet be said to be completely established, and the stratigraphically intervening Actonian Stage has not yet yielded identifiable trinucleids. In Bohemian faunas *Onnia*, as represented by *O. ornata* (Sternberg), is long ranging and earlier than the British occurrences, but appears to be closely related only to *O. gracilis*, so that one could postulate a migration from Europe during the Onnian, giving rise to the Shropshire *Onnia gracilis* as an alternative, and perhaps in addition, to evolution from an indigenous stock. As has been noted earlier in this paper, there are difficulties in the acceptance of a simple line of evolution within the relatively short sequence of the Shropshire Onniae. *O.? cobboldi* and *O. superba* resemble each other more closely than they do the stratigraphically intermediate *O. gracilis*, and the mutual relationships are not yet fully resolved, though the figured *O.* aff. *superba* suggests a connection. After the close of the Onnian Stage in England and Wales *Onnia* has been found only in southern Norway, and the history of the group is, on the whole, poorly known. It may be noted that according to Bancroft (*in* Lamont, 1948 : 416) the *Onnia gracilis* Zone in the Cross Fell Inlier may follow a disconformity in the succession. In the Welshpool district the Gwern-y-brain Shales containing *Onnia gracilis* overlie the Gaer Fawr Beds of Longvillian age, and it is possible that an extension of marine conditions over parts of England and Wales during Onnian times led to a renewal of links with extra-British faunas in southern Europe which had not been in evidence since the early part of the Caradoc Series.

Of the early forms of *Broeggerolithus* the link between *B. broeggeri* and *B. globiceps* is not yet established, and the stratigraphically intermediate *B. soudleyensis* probably represents only an off-shoot which left the main *Broeggerolithus* line of descent during the Lower Soudleyan and continued a parallel line of development up to and including the lower part of the Upper Longvillian without undergoing any significant change of fringe-type. Whittard (1958 : 71) has now discovered *Cryptolithus* (*s.s.*) in the Upper Llanvirn Series and the Llandeilo Series of the Shelve Inlier, so that one can no longer support Bancroft's claim (1935 : 334) that *Broeggerolithus* from the Caradoc gave rise to *Cryptolithus* in the U.S.A., presumably by means of migration from Britain.

Of the other Harnagian genera mentioned earlier in this paper, *Salterolithus* continued throughout the Harnagian and the Lower Soudleyan, when apparently it became extinct without, so far as is known, giving rise to any later forms. The related *Smeathenia* is restricted, both horizontally and vertically, in its distribution, and may represent only a short-lived local development in which the formation of rows of pits external to the girder reached an unusually high level.

V. REFERENCES

ANGELIN, N. P. 1854. *Palaeontologia Scandinavica.* ix + 92 pp., 42 pls. Lund.

BANCROFT, B. B. 1928. On the notational representation of the rib-system in Orthacea. *Mem. Proc. Manchr. Lit. Phil. Soc.*, **72** : 53–90, pls. 1–3.

—— 1928*a*. The Harknessellinae. *Mem. Proc. Manchr. Lit. Phil. Soc.*, **72** : 173–196, pls. 1, 2.

—— 1929. Some new genera and species of Strophomenacea from the Upper Ordovician of Shropshire. *Mem. Proc. Manchr. Lit. Phil. Soc.*, **73** : 33–65, pls. 1, 2.

—— 1929*a*. Some new species of *Cryptolithus*, (*s.l.*), from the Upper Ordovician. *Mem. Proc. Manchr. Lit. Phil. Soc.*, **73** : 67–98, pls. 1, 2.

—— 1933. *Correlation Tables of the Stages Costonian-Onnian in England and Wales.* 4 pp., 3 tables. Blakeney, Glos. (Privately printed).

—— 1935. The descent of Genera in Cryptolithinae. *Trans. Geol. Soc. Glasgow*, **19** : 333–334.

—— 1945. The brachiopod zonal indices of the Stages Costonian to Onnian in Britain. *J. Paleont.*, Tulsa, **19** : 181–252, pls. 22–38.

—— 1949. Upper Ordovician trilobites of zonal value in South-east Shropshire. *Proc. Roy. Soc.*, London (B) **136** : 291–315, pls. 9–11. (Edited by A. Lamont).

CAVE, R. 1957. *Salterolithus caractaci* (Murchison) from Caradoc strata near Welshpool, Montgomeryshire. *Geol. Mag., Lond.*, **94** : 281–290, pl. 10.

CAVE, R. & DEAN, W. T. 1959. Four British Ordovician species of Dalmanelloid brachiopod. *Palaeontology*, London, **1** : 292–297, pl. 53.

COOPER, B. N. 1953. Trilobites from the Lower Champlainian Formations of the Appalachian Valley. *Mem. Geol. Soc. Amer.*, Baltimore, **55** : i–v, 1–69, pls. 1–19.

DEAN, W. T. 1958. The faunal succession in the Caradoc Series of South Shropshire. *Bull. Brit. Mus.* (*Nat. Hist.*) *Geol.*, **3** : 191–231, pls. 24–26, 4 figs.

HARPER, J. C. 1947. The Caradoc fauna of Ynys Galed, Caernarvonshire. *Ann. Mag. Nat. Hist.*, London (11) **14** : 153–175, pls. 6, 7.

—— 1956. The Ordovician succession near Llanystwmdwy, Caernarvonshire. *Liv. Manchr. Geol. J.*, Birkenhead, **1** : 385–393, 1 fig.

LAMONT, A. 1935. The Drummuck Group, Girvan ; a stratigraphical revision, with descriptions of new fossils from the lower part of the group. *Trans. Geol. Soc. Glasgow*, **19**: 288–332, pls. 7–9.

—— 1941. Trinucleidae in Eire. *Ann. Mag. Nat. Hist.*, London (11) **8** : 438–469, pl. 5.

—— 1948. B. B. Bancroft's geological work. 2. Upper Ordovician of the Cross Fell Inlier. *Quarry Manager's J.*, Mexborough, **31** : 416–418, 466–469, 1 pl., 2 figs.

La Touche, J. D. 1884. *A Handbook of the Geology of Shropshire.* 99 pp., 22 pls. London & Shrewsbury.

McCoy, F. 1851. A systematic description of the British Palaeozoic fossils in the Geological Museum of the University of Cambridge, *In* Sedgwick, A., *A synopsis of the classification of the British Palaeozoic rocks*, **1** : 184 pp., 11 pls. London & Cambridge.

Murchison, R. I. 1839. *The Silurian System founded on geological researches in the counties of Salop, Hereford, Radnor, Montgomery, Caermarthen, Brecon, Pembroke, Monmouth, Gloucester, Worcester and Stafford ; with descriptions of the coal-fields and overlying formations.* xxxii + 768 pp., 40 pls. London.

—— 1854. *Siluria.* xv + 523 pp., 37 pls. London.

—— 1859. *Siluria.* 3rd edit. xix + 592 pp., 41 pls. London.

—— 1867. *Siluria.* 4th edit. xvii + 566 pp., 41 pls. London.

—— 1872. *Siluria.* 5th edit. xvii + 566 pp., 41 pls. London.

Pocock, R. W., Whitehead, T. H., Wedd, C. B. & Robertson, T. 1938. Shrewsbury District including the Hanwood Coalfield (One-inch Geological Sheet 152 New Series) *Mem. Geol. Surv. Gt. Britain*, London. xii + 297 pp., 8 pls.

Pugh, W. J. 1928. The geology of the district around Dinas Mawddwy (Merioneth). *Quart. J. Geol. Soc. Lond.*, **84** : 345–381.

Raymond, P. E. 1913. Some changes in the names of genera of trilobites. *Ottawa Nat.*, **26** : 137–142.

—— 1913*a*. A further note on *Cryptolithus* versus *Trinucleus*. *Ottawa Nat.*, **27** : 26–30.

—— 1925. Some trilobites from the lower Middle Ordovician of Eastern North America. *Bull. Mus. Comp. Zool.*, Harvard, **67** : 1–180, pls. 1–10.

Reed, F. R. C. 1912. Notes on the genus *Trinucleus*. Part 1. *Geol. Mag., Lond.* (5) **9** : 346–353, pl. 18.

—— 1912*a*. Notes on the genus *Trinucleus*. Part 2. *Geol. Mag., Lond.* (5) **9** : 385–394, pl. 19.

—— 1914. Notes on the genus *Trinucleus*. Part 3. *Geol. Mag., Lond.* (6) **1** : 349–359, pls. 28, 29.

—— 1932. Notes on two species of the genus *Ampyx*. *Geol. Mag., Lond.*, **69** : 205–209, pl. 11.

Rusconi, C. 1956. Fósiles ordovicicos de la Quebrada de los Bueyes (Mendoza). *Rev. Mus. Hist. Nat. Mendoza*, **9** (1–2) : 3–15, 1 pl.

Salter, J. W. 1853. Figures and descriptions illustrative of British organic remains. *Mem. Geol. Surv. Gt. Britain*, London, **7** : 1–78, pls. 1–10.

Schmidt, F. 1894. Revision der Ostbaltischen Silurischen Trilobiten. 4. Calymmeniden, Proetiden, Bronteiden, Harpedinen, Trinucleiden, Remopleuriden und Agnostiden. *Mém. Acad. Sci. St. Pétersb.*, **42**, 5 : 1–93, pls. 1–6.

Shackleton, R. M. 1938. *In* discussion of H. B. Whittington's paper "The geology of the district around Llansantffraid ym Mechain, Montgomeryshire". *Quart. J. Geol. Soc. Lond.*, **94** : 459.

Shaw, A. B. & Stubblefield, C. J. 1950. *Trinucleus* Murchison, 1839 as a *nomen conservandum*. *J. Paleont.*, Tulsa, **24** : 624–625.

Shirley, J. 1931. A redescription of the known British Ordovician species of *Calymene* (*s.l.*). *Mem. Proc. Manchr. Lit. Phil. Soc.*, **75** : 1–35, pls. 1, 2.

—— 1936. Some British Trilobites of the Family Calymenidae. *Quart. J. Geol. Soc. Lond.*, **92** : 384–422, pls. 29–31.

Skjeseth, S. 1952. On the lower *Didymograptus* Zone (3B) at Ringsaker, and contemporaneous deposits in Scandinavia. *Norsk. geol. tidsskr.*, Oslo, **30** : 138–182, pls. 1–5.

Stetson, H. C. 1927. The distribution and relationships of the Trinucleidae. *Bull. Mus. Comp. Zool.*, Harvard, **58** (2) : 87–104, 1 pl.

Størmer, L. 1930. Scandinavian Trinucleidae, with special reference to Norwegian species and varieties. *Skrift. Norske Vid.-Akad.*, Oslo, **1**, Mat.-Nat. Kl.: iv, 1–111, pls. 1–14.

—— 1940. Early descriptions of Norwegian trilobites. The type specimens of C. Boeck, M. Sars and M. Esmark. *Norsk. geol. tidsskr.*, Oslo, **20** : 113–151, pls. 1–3.

—— 1945. Remarks on the *Tretaspis* (*Trinucleus*) Shales of Hadeland, with description of trilobite faunas. *Norsk. geol. tidsskr.*, Oslo, **25** : 379–426, pls. 1–4.

TERMIER, G. & H. 1950. Paléontologie Marocaine. 2. *Actual. Sci. Industr.*, Paris, **1095** : 1–279, pls. 184–241.

THORSLUND, P. 1940. On the Chasmops Series of Jemtland and Södermanland (Tvären). *Sverig. Geol. Unders. Afh.*, Stockholm (C) **436** : 1–191, pls. 1–15.

VOGDES, A. W. 1890. A bibliography of Paleozoic Crustacea from 1698 to 1889 including a list of North American species and a systematic arrangement of genera. *Bull. U.S. Geol. Surv.*, Washington, **63** : 1–177.

WADE, A. 1911. The Llandovery and associated rocks of north-eastern Montgomeryshire. *Quart. J. Geol. Soc. Lond.*, **67** : 415–459, pls. 33–36.

WHITTARD, W. F. 1955. The Ordovician trilobites of the Shelve Inlier, West Shropshire, **1** : 1–40, pls. 1–4. *Palaeontogr. Soc.* [*Monogr.*] London.

—— 1956. The Ordovician trilobites of the Shelve Inlier, West Shropshire, **2** : 41–70, pls. 5–9. *Palaeontogr. Soc.* [*Monogr.*] London.

—— 1958. The Ordovician trilobites of the Shelve Inlier, West Shropshire, **3** : 71–116, pls. 10–15. *Palaeontogr. Soc.* [*Monogr.*] London.

WHITTINGTON, H. B. 1938. The fauna of the Lluest Quarry, Llanfyllin (*Wattsella horderleyensis* Super-Zone), and its correlation. *Proc. Geol. Ass. Lond.*, **49** : 49–54, pl. 6.

—— 1938*a*. The geology of the district around Llansantffraid ym Mechain, Montgomeryshire. *Quart. J. Geol. Soc. Lond.*, **94** : 423–457, pls. 38, 39.

—— 1940. On some Trinucleidae described by Joachim Barrande. *Amer. J. Sci.*, Washington, **238** : 241–259, pls. 1–4.

—— 1941. The Trinucleidae—with special reference to North American genera and species. *J. Paleont.*, Tulsa, **15** : 21–41, pls. 5, 6.

—— 1950. Sixteen Ordovician genotype trilobites. *J. Paleont.*, Tulsa, **24** : 531–565, pls. 68–75.

—— 1954. *Onnia* (Trilobita) from Venezuela. *Breviora*, Cambridge, Mass., **38** : 1–5, 1 pl.

WHITTINGTON, H. B. & WILLIAMS, A. 1955. The fauna of the Derfel Limestone of the Arenig district, North Wales. *Philos. Trans.*, London (B) **238** : 397–430, pls. 38–40.

WILLIAMS, A. 1948. The Lower Ordovician Cryptolithids of the Llandeilo District. *Geol. Mag. Lond.*, **85** : 65–88, pl. 6.

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